NUTS & VOLTS
MAGAZINE

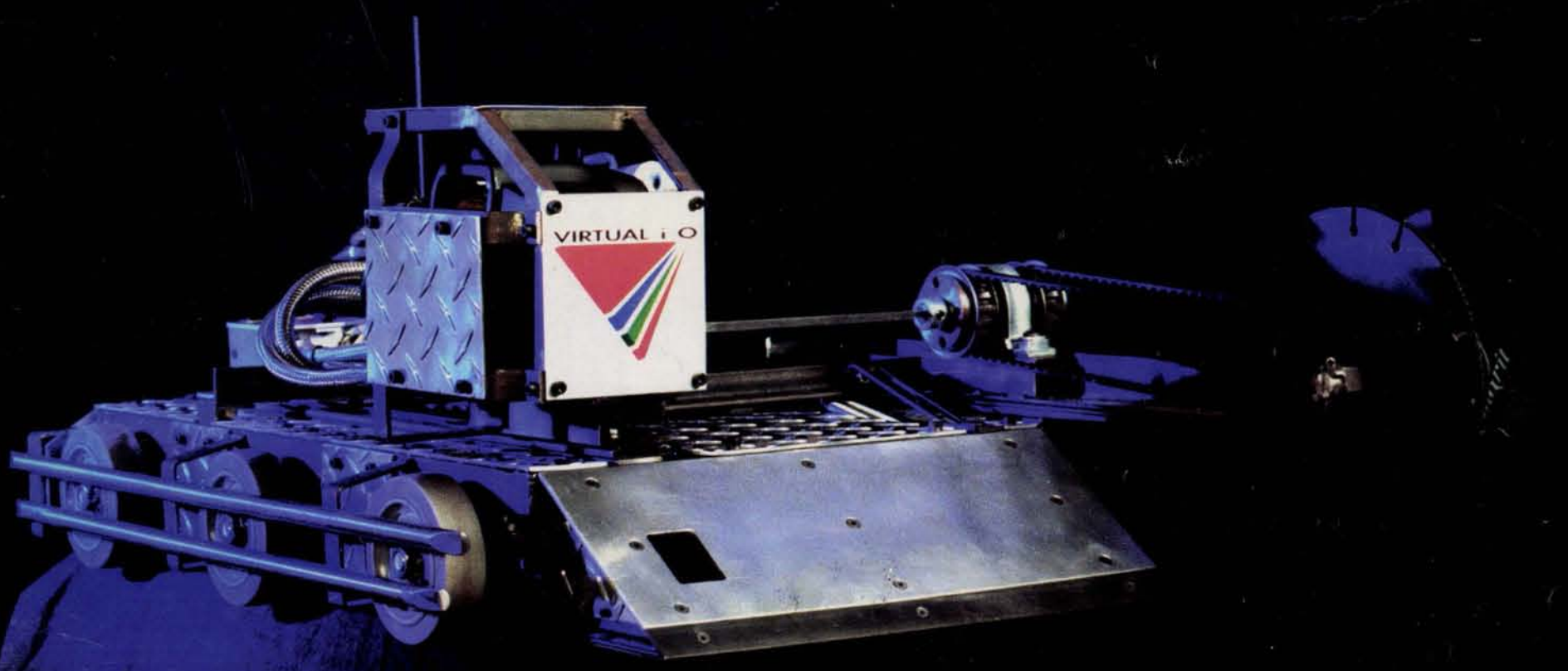
OUR 18th YEAR

$3.50
VOL. 18 NO. 3
MARCH 1997

Exploring Electronics And Technology For The Hobbyist And Professional

Robot Wars

Who will survive?



THE AGAMEMNON

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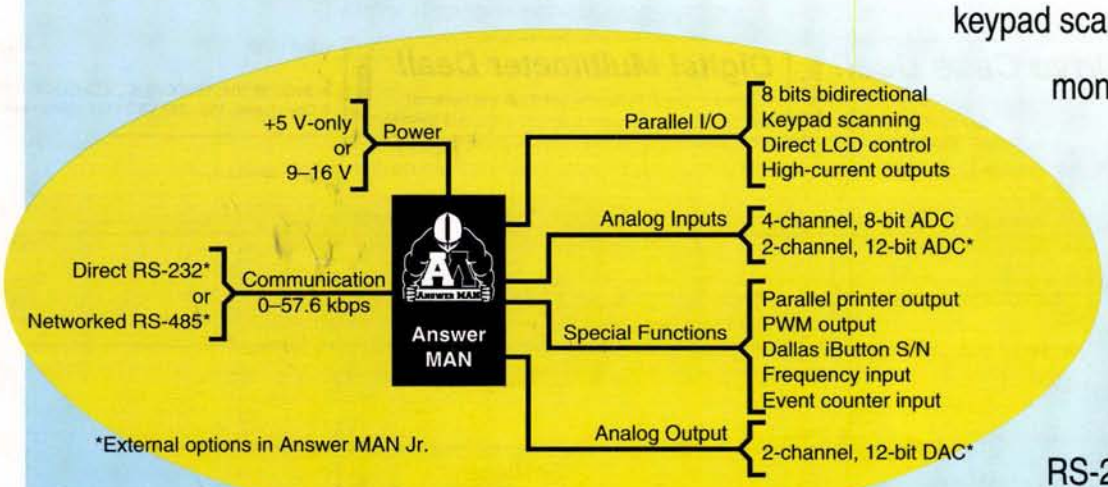
Got control problems? In today's competitive engineering world, often the project and sometimes even your job depends on how quickly you can put together a cost-effective solution. Unfortunately, when those solutions involve configuring multidropped data acquisition and control systems, everyone heads for the hills. That was, until Answer MAN arrived!

Answer MAN incorporates digital I/O, 8- and 12-bit analog I/O, power regulation, and serial line drivers along with powerful firmware for keypad scanning, LCD control, analog limit monitoring, data averaging, frequency and event counting, PWM output, and reading Dallas iButton™ serial numbers in a tiny 28-pin DIP package. Answer MAN can be used independently (RS-422, RS-232), or hundreds can be networked together (RS-485).



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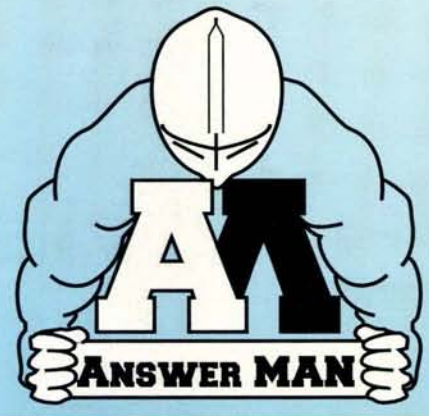

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HSC#16496 Version 1 Amp Board **$24.95**
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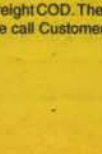
- Brand New, 90-day warranty



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- You keep buying us out, we keep looking for more!
- VESA-Local Bus motherboard has 5 slots (2 VLB)
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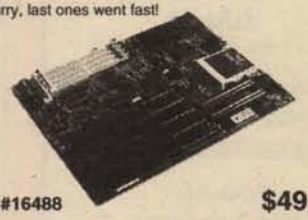
- 90-day HSC Warranty
- Hurry, last ones went fast!



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- Open frame, 100 - 240 VAC input, brand new!

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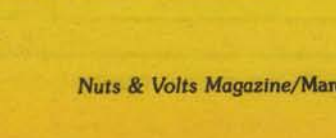

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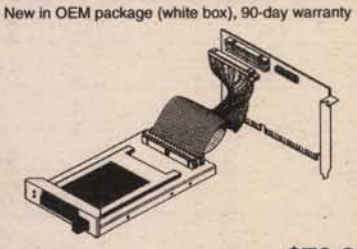

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NUTS & VOLTS MAGAZINE

Published Monthly By
T & L Publications, Inc.
430 Princeland Court
Corona, CA 91719
(909) 371-8497
FAX (909) 371-3052

E-Mail
editor@nutsvolts.com
URL
http://www.nutsvolts.com

Subscription Order ONLY Line
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All submissions should be on 5-1/4 or 3-1/2 inch diskettes and include hard copy as well. If return of materials is requested, include a SASE with your submission.

Deadlines should be discussed in advance with the editor, but generally all material should be submitted by the 1st of the month for the next month's issue.

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Nuts & Volts Magazine is published monthly for $19.00 per year by T&L Publications, Inc., 430 Princeland Court, Corona, CA. Application to mail at 2nd class postage rates is pending at Corona and San Diego. POSTMASTER: Send address changes to Nuts & Volts Magazine, 430 Princeland Court, Corona, CA 91719.

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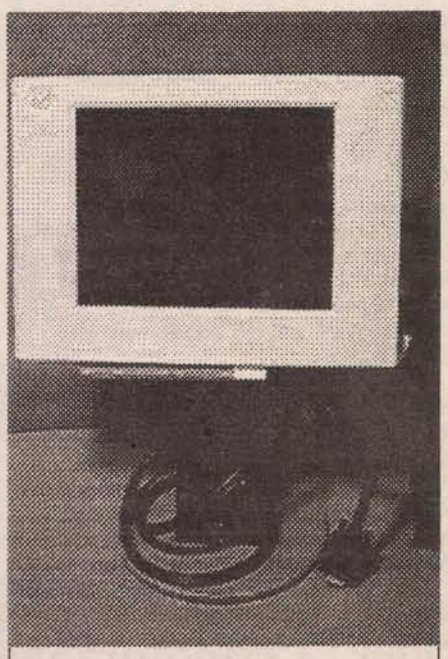

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reader FeedBack

Dear Nuts & Volts:

So reader Tony Farrell, who appears to work for IBM (tony_farrell@ibm.net), thinks that "95% of all PC support problems are related to Microsoft, since Microsoft has 90% of the market." His solution is the NC which he envisions as a monolithic system of hardware-identical stations. The identical hardware eliminates the remaining 5% of all support problems, he asserts. He asserts that "any company would be a fool" not to lease all its desktop equipment and software from one of the major remaining main-frame players, including IBM. "After all," he concludes, "do you own your car or do you lease?"

I'm sure Corel will be dismayed to know that Microsoft still has 90% of the software market, in spite of their massive WordPerfect promotions and the full page magazine ads proclaiming theirs is now the most popular office suite. Lotus (now owned by IBM) will be equally unhappy since they are under the impression that Notes and the Lotus Smart Suite have much more than a 5% market share. Novell will be even more discouraged. They think they still have over 50% of the networking software market. Or, perhaps Mr. Farrell is referring to the predominance of Microsoft Windows operating systems (OS) in the PC world. To get rid of this onerous support problem, he suggests companies lease NCs, complete with a non-Windows OS from IBM. Of course, that same IBM was so unsuccessful at developing and marketing its OS/2 competition for Windows that it never released OS/2 for the IBM Power PC. The IBM PPC was sold with Windows NT as its OS. But, maybe IBM will do better with the NC OS.

Even if all support problems vanish with Mr. Farrell's leased system, so will any software options. On a PC you can run DOS, or Windows, or OS/2, or a flavor of UNIX, or one of several proprietary systems. Even if you choose Windows, you can run programs from any number of vendors besides Microsoft. With the leased NC system, you'll run only the software those three-to-five "free" support techs who come with the system allow you to run. And don't expect to do any Web surfing outside the NC firewall. The support time will suffer if you're allowed to capture "unauthorized" Java or ActiveX controls from external Web pages. Only approved controls can be allowed on your company system, otherwise you'd have the same anarchy and support headaches that the enterprise PC support people have to deal with today. Of course, you won't have to worry about limited software options when your network goes down. Without the connection to the mainframe, you won't have any programs to run or data to access.

Mr. Farrell's last point is most interesting. Do most companies lease vehicles? Probably, but because of tax advantages, not features, service, or support. Are leased cars simpler to service than purchased cars? No, they're the same cars. The NC may be a superior system to the PC from a support standpoint for some enterprises. If so, it will be superior regardless of how it's financed. Lease or outright purchase is a financial decision made outside of hardware reliability or support cost options. If a leased NC system is cheaper for an enterprise than a leased PC system, then a purchased NC system would be cheaper for them than a purchased PC system.

Incidentally, I'm not a spokesperson for Microsoft, I just work here. My opinions are my own and aren't necessarily those of anyone else at Microsoft, including Bill G.

Noel Nyman
via Internet

Dear Nuts & Volts:

Reference the article "High-Quality Desktop Linear Supply for Automotive Electronics" in the Jan. '97 issue. Please advise your readership that the Pyramid Gold Series model PS-12K power supply has always been available from:

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Stas J. Andrzejewski
Anaheim, CA

Dear Nuts & Volts:

John Iovine's article "NiCad Battery Charger" in your Dec. '96 issue was read with interest. In it, he repeated a myth that has all but disappeared. NiCads do not have memory. The presence of a dead/shorted cell in a battery (several cells in series) gives the impression of memory. If "memory" is suspected, check the individual cell voltages and one with little or no voltage will be found. Discharging and recharging (cycle charging) the battery may give the impression that the battery is successfully recharged, but the bad cell will fail again very quickly.

This appears as if memory existed. "Dead" cells may be rejuvenated by shocking them with massive currents from a large capacitor or a current regulated power supply. Such cells are no longer reliable in critical applications such as in model airplane flight batteries. To be safe, if all cells in the battery are from the same purchase group (age/type) discard the battery.

George Wilson W1OLP
geowilson@juno.com

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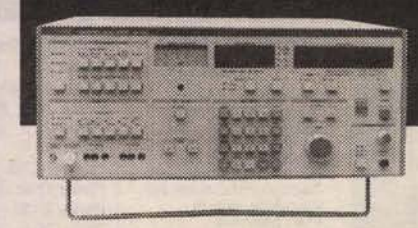

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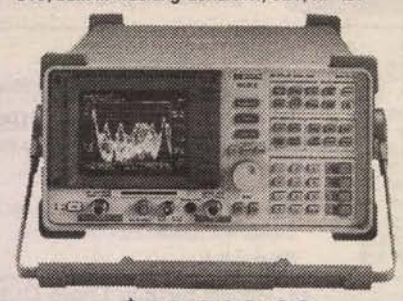

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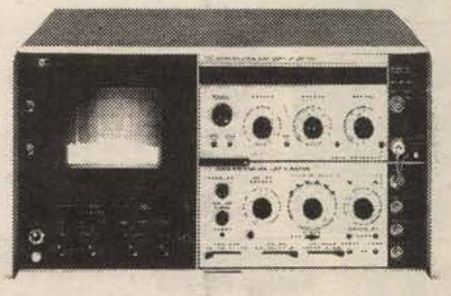

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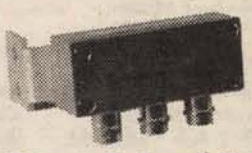

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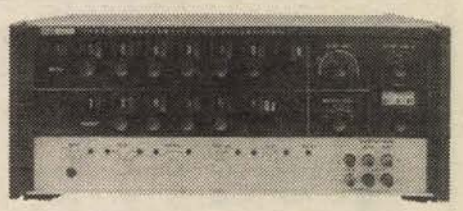

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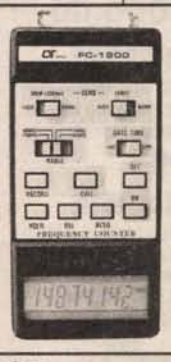

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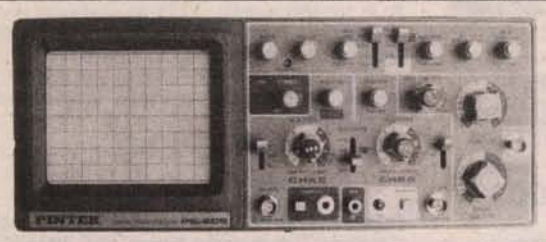

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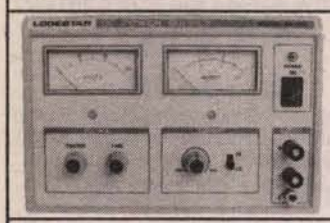

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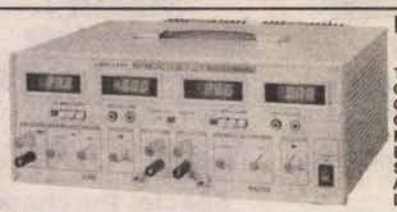

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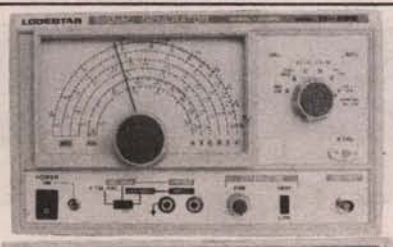

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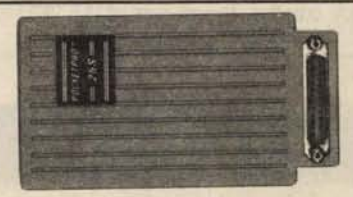

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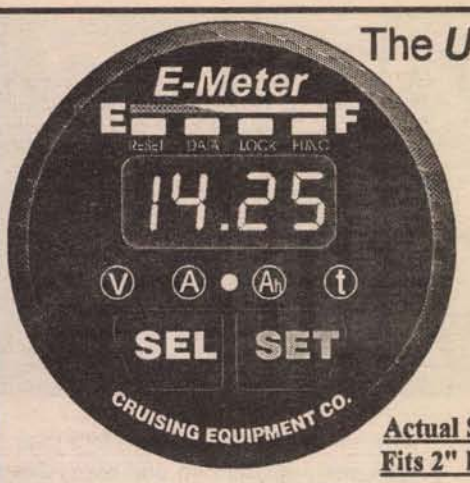

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SIDE-SCANNING SONAR TO THE RESCUE

by Gordon West

Let's have a race. You are the electromagnetic radio wave, traveling at a velocity of 186,000 miles per second. I'll be the audio wave, traveling at one mile per second. I know that the radio wave is going to win the speed contest in air, but what about in water?

Our race is between the surface of the water down to 100 feet, and then back to the surface. Ready? GO!

The sound wave beats. The radio wave loses. Why? Radio waves don't propagate more than a few feet in water, and sound waves can go for hundreds of miles under water.

Radio waves are used for more than just communications in the air — they are also used for ranging. This is called radar, and a radar mile refers to nautical miles which are 15 percent longer than statute miles, and the radio wave traveling at 186,282 statute miles per second will travel 982 feet in a microsecond.

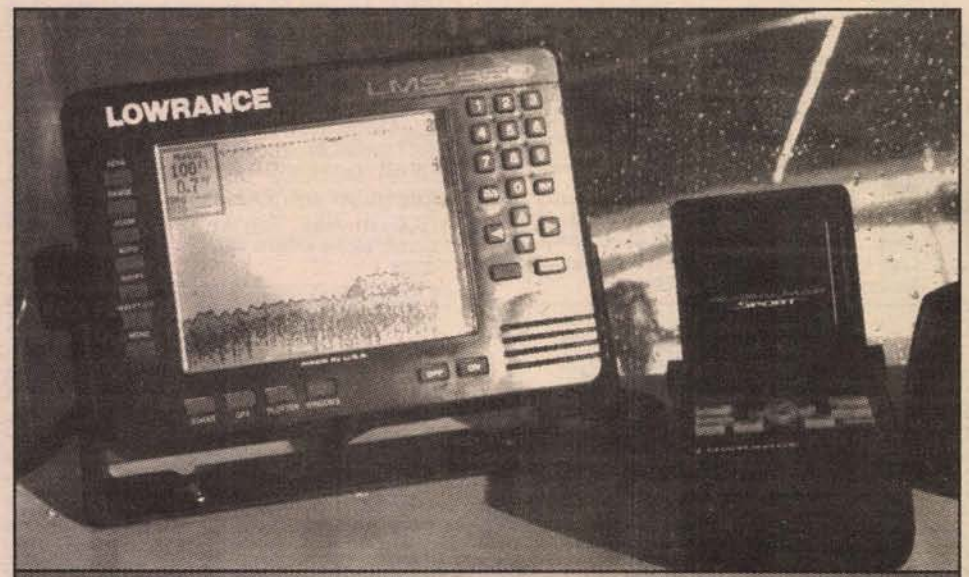
By dividing by two (reflected signals must make a two-way trip), one can accurately gauge an object's distance. This works well for boats, radar land stations, and ships at sea, but won't work through the water. The attenuation of sea water is so great that radio waves hardly penetrate the surface of the ocean.

Acoustic waves between 50,000 Hz (cycles per second) to 200,000 Hz travel at an approximate velocity of 4,800 feet per second in sea water. That is 4,800 feet per second, not a microsecond. While acoustic waves are dramatically slower in their speed through water, they can travel infinitely further in water than what a radio wave might do when submerged.

Acoustic detection of the bottom was first accomplished by seamen pounding on the steel hull below the water line, and then listening for an echo off of the bottom. Then entered the Fathometer™, a registered trademark of Raytheon Corporation. It would send down acoustic pulses to the bottom, and these would be received back with a time difference equal to the amount of water below the hull.

The device that changes electrical energy at the depth sounder control and display head to acoustic energy is called the underwater transducer. The transducer uses a crystal element that sends out an acoustic wave when excited by voltage. This same element is also sensitive to a return echo, converting specific frequency pressure waves back into an electrical pulse that then triggers the display head to illustrate how deep the bottom is.

Underwater marine depth-sounders have come a long way from the spinning bulb type found in the 50s. Now they use liquid crystal displays, and the displays can not only show you bottom, but all the fish and stuff in between. And if you're into fresh water or salt water fishing, names like Humminbird, Lowrance, Eagle, Apelco, and Furuno should ring a bell. These are the major suppliers of underwater depth sounders that can also register fish and everything else in between.



High-resolution $600.00 recorder showing a wreck on the ocean floor (hump on the right of screen).

But boaters didn't necessarily always want to see a panoramic view of the ocean floor — so many times you will see a depth indicator on a small boat that is nothing more than flashing digits indicating feet or fathoms below the underwater transducer But the avid fisherman wants a graphic presentation of everything below, so they would opt for the depth recorder.

Everything on the bottom and a past history of what you went over would scroll from right to left on an LCD screen. The more expensive your recorder, the more pixels of definition you would get, and the smaller the little irregularities on the bottom you could detect; $100.00 lets you look at the ocean floor in little tiny blocks, but a $600.00 depth recorder gives you as much detail as what you would expect from an older chart paper system used by the commercial fishermen.

As depth recorders improved with microprocessor-driven brains, so did the underwater transducer. A single underwater transducer was then re-developed into three separate crystals, each crystal capable of detecting fish and bottom to the left of the boat, straight down, and to the right of the boat. Some manufacturers claimed this was a three-dimensional look at the bottom, but whatever it was, it gave you the ability to sweep the bottom and see activity below and off to the left and right (port and starboard for you mariners).

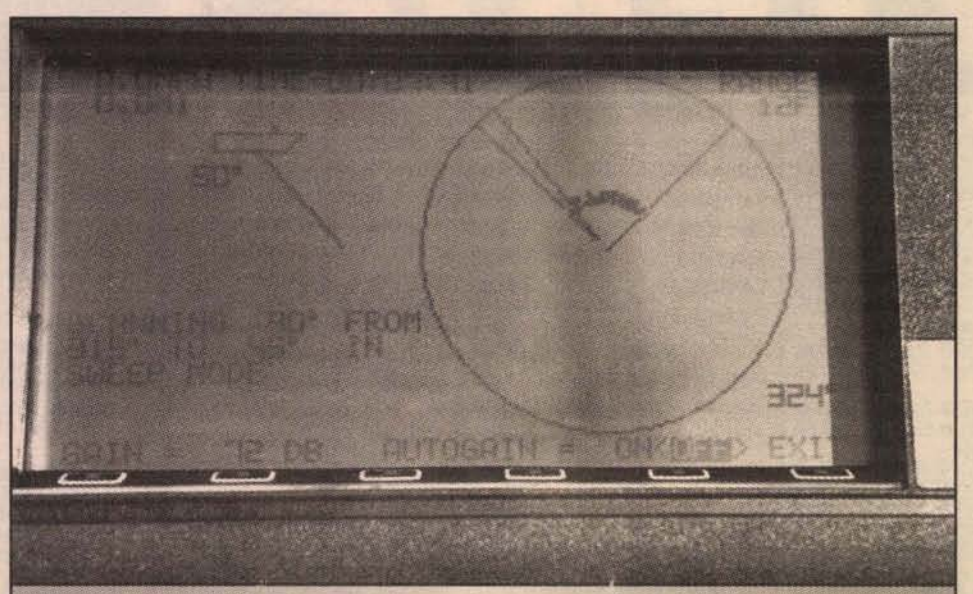
Then there was the transducer that could scan fore, down, and aft. And it was the "fore" aspect of underwater transducer technology that really got the attention of many boat owners. Just think — you could see ahead of you to avoid submerged tree trunks, sand bars, and other prop-busting obstacles. Manufacturers like Apelco, Echo Pilot, and Interphase were quick to promote the added safety feature of an underwater depth sounder that could actually detect objects ahead. Well, sort of.

The Apelco and Echo Pilot would send energy down at a 45-degree angle ahead of the boat. If you weren't moving real fast, this could certainly keep you off of a shoaling situation, or let you see that there is something ahead by a few feet off the bow of your small boat. But for detecting stuff floating on the surface of the water, these 45-degree forward-looking sounders wouldn't do the job. They weren't intended to, and they work quite nicely in letting you see bottom conditions changing ahead.

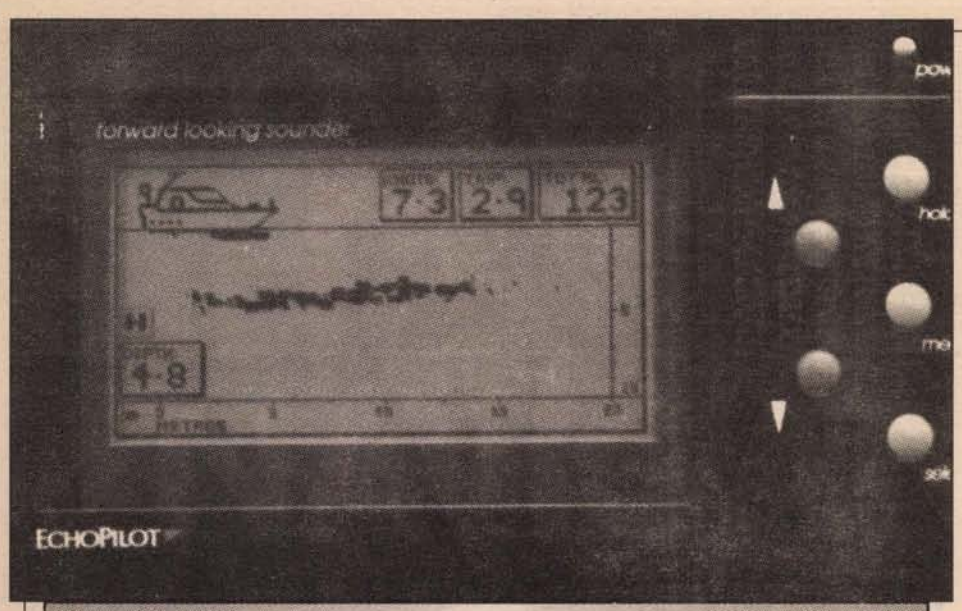
A company called Interphase, in conjunction with transducer manufacturer Airmar Corporation, developed a phased array transducer assembly with eight crystal elements that were electronically phased within the depth recorder head. Instead of firing one element at a time, the microprocessor brains of the Interphase recorder would combine the transmitting and receiving elements to form a steerable beam ahead to look at everything from water level to straight down. At last, a sounder that might detect something floating on the water dangerously close ahead.

Not really. When you sound an acoustic pulse from below the water up to the surface of the water, you detect the water surface as an echo. The regular echo of the water surface would cause a false reading on the echo sounder screen as something ahead. Yes, what is ahead is the surface of the water!

But by careful adjustment of



Underwater scanning, much like radar.



Forward sounding sonar.

the Interphase electronics, you could steer a beam with a slight down tilt of about 10 degrees, and this could allow you to see out about 100 feet ahead, and find obstacles ahead that could dent your bow or break your prop. But the floating obstacles needed to have plenty of depth to them to be detected ahead, so the sounder manufacturers were avoiding any wording that might lead mariners to think that this was a collision-avoidance system. It just wouldn't work.

To be able to sound ahead and precisely detect incoming objects just floating below the surface of the water requires a relatively large transducer element. The transducer element is similar to a spotlight lens and reflector. The bigger the reflector, the tighter the beam. Same thing with underwater transducers — the bigger the transducer element, the tighter you can form a beam in order to see ahead. Or see down. Or see to the sides and aft, too.

The steerable underwater transducer from Coastal Navigator.

To be able to do this, a phased array transducer would be too expensive for casual mariners, so a large transducer head is put into a mineral oil pod and can be rotated up and down, as well as completely around in a circle. This we know as side-scanning sonar, and it is found on big research boats and commercial boats. At about $8,000.00 +++.

A less expensive (under $2,000.00) underwater scanning sonar has been in use for many years from a company called Coastal Navigator (Woodenville, WA). A steerable underwater transducer beams out hundreds of watts of acoustic energy to detect underwater targets ahead, to the side, or to scour the bottom for tell-tale signs of fish, wrecks, or just about anything else down there.

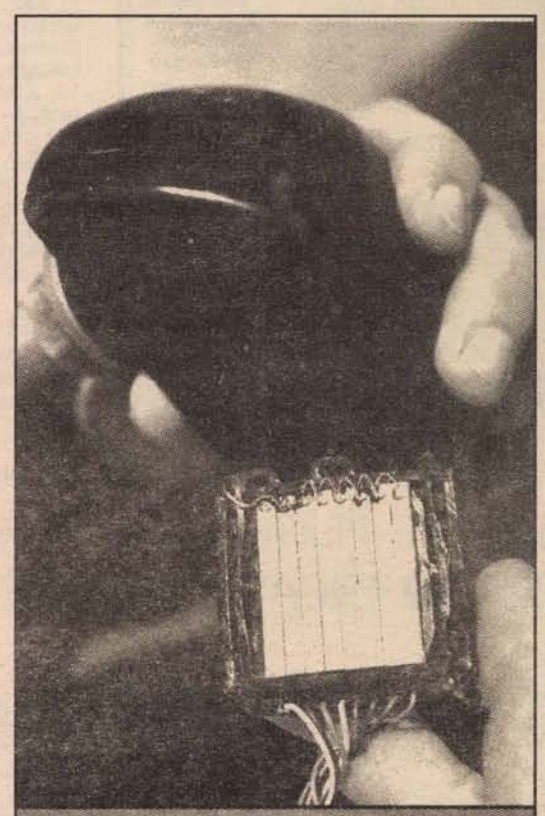
Many lake and ocean lifeguard rescue agencies use the steerable beam during emergency search and rescues. In the case of a missing person just outside the surf line in the ocean, the Coastal Navigator unit picked out a target floating 10 feet below the water, and the rescue was quickly made.

In another case, a small aircraft ditched into a big lake where one of the rescue vessels was operating one of these underwater search sonars. By the time the rescue vessel got into the area where the plane hit the water, there was nothing left floating. But the underwater sounder was able to quickly spot where the plane had settled on the lake floor bottom, and two occupants were rescued and saved.

The underwater sonar can read similar to an over-water marine radar. On the screen, your boat is always positioned in the center, with the bow pointing straight up. By positioning the crosshairs over an obstacle, the underwater sonar can give you distance and bearing to the underwater target. When an alarm is set, distance and bearing to the target will automatically be displayed anytime the alarm is triggered.

In the regular bottom mode, the push of a button can change the transducer from 200 KHz high-resolution sweeping to 50 KHz wide-area viewing. This allows you to look at the ocean floor, and spot targets below and several hundred feet off to each side of your vessel.

For rescue agencies looking for a specific underwater target, the sounder can even work in the split-screen zoom mode for a closer look. You can even plug this underwater sonar into an existing GPS output so you can view pertinent navigational data on the screen, as well as your latitude and longitude.



Close-up view of the eight crystal phased array transducer from Interphase.

And, if you are into fishing and can never seem to get right over where the fish are biting, the scanning sonar can let you quickly find fish off to the sides, get over to them, and then stay with the school of fish as they're feeding on your bait. If you are out on the water, and want more than just flashing numbers for water depth, do consider one of the new breeds of underwater sounders and sonars. New technology now packs plenty of bang for the buck. **NV**

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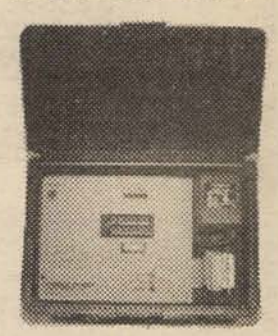

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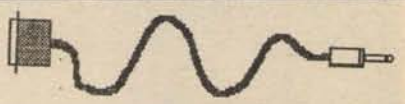

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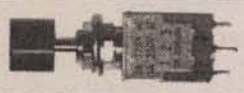

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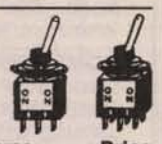

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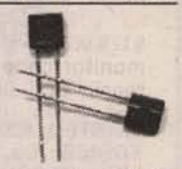

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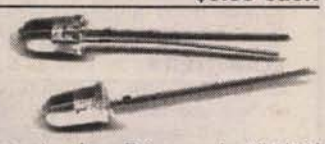
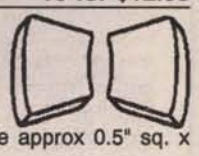


BLUE LED

T1-3/4 blue water clear. Price good until 4/30/97.

SE5064S **10 for $12.95**



NEODYMIUM MAGNETS

100+ Gauss each. Size approx 0.5" sq. x 0.125".

92N003 **6 for $9.95**

CARBON COMP RESISTOR ASSORTMENT

10% and 20% tolerance. Many individually packaged.

94P031 **5 Lbs. for $9.95**

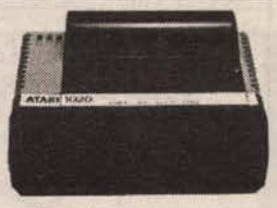
We have 1000s of carbon comp resistors in stock!

ELECTRONIC COMPASS KIT

A Global Positioning System receiver may be the ultimate location finder device, but for casual hiking, biking or camping this amazing digital electronic compass is an economical alernative. The compass kit uses an advanced Hall-effect sensor to detect the earth's magnetic field and converts te information into a directional display. Runs on 9V battery.

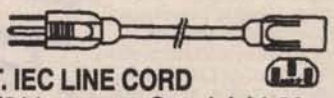
97K001 **$32.00 each**

ATARI 1020 COLOR PRINTER



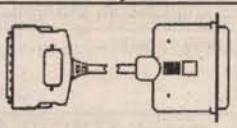
For all Atari 8-bit computers. (Not PC-compatible!) Package includes: printer, power supply, software, pens, paper and interface cable. These are new units in factory sealed boxes.

94C037 **$14.95 each**



6-FT. IEC LINE CORD

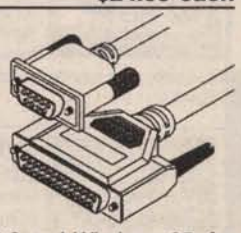
95W011 **Special $1.00 each**



SCSI-II to SCSI-I CABLE

Two feet long.

97W001 **$24.95 each**



LAPLINK SERIAL CABLE

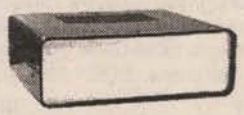
Six foot double-headed (DB9F to DB25F) cable. Works with DOS 6.2 and Windows 95, for direct copying directly from one computer to another.

97W002 **$5.95 each**

HI VOLTAGE 'LYTIC

330µF, 250V. Mini snap-in type, measures only 2.5cm x 3cm.

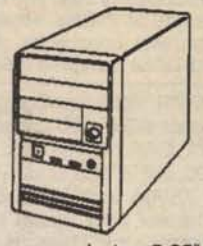
97P001 **$4.95 each**



STEEL ENCLOSURES

Features include ventilation holes, self-adhesive rubber feet. Front and rear panels are 0.05" aluminum alodine painted white. Top and bottom covers are 0.04" phosphated steel painted black.

GC3119A (2.5" x 6" x 7") **$14.00**
GC3119G (3.5" x 8" x 7") **15.00**



COMPUTER CASE & POWER SUPPLY

Mini tower case with power supply, two 5.25" and two 3.5" external bays, plus one internal bay for hard drive. LEDs for power, turbo and HDD.

97C001 **$34.95 each**

DELUXE 101-KEY KEYBOARD WITH PROTECTIVE COVER

Plastic "membrane" cover protects keys from dust, liquids, etc.

97C002 **$14.95 each**

1MBx9, 70nS 30-PIN SIMMs

Matched sets.

97C003 **Set of Four $29.95**

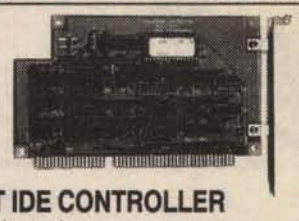
256Kx9, 100nS 30-PIN SIMMs

97C005 **Set of Four $5.00**

200MB SCSI HARD DRIVES

New, factory-wrapped. Connor CP30200.

97C004 **$69.95 each**



16-BIT IDE CONTROLLER

Hard drive only.

96C012 **$2.99 each**

150-WATT MINI TOWER POWER SUPPLY

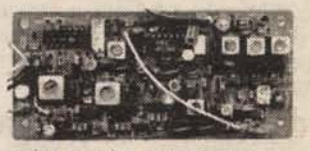
Pulled from unused equipment.

96C009 **$9.95 each**

KEYBOARD EXTENSION CABLE

Ten-foot cable with DIN 5 male to DIN 5 female connectors.

KB-10 **$1.49 each**

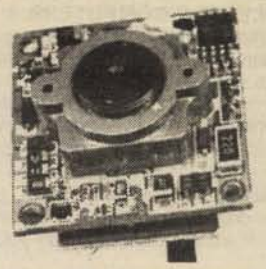


TV AUDIO DEMODULATOR

Unused unit from cable TV box takes channel 3, 4 or 5 signal and demodulates the audio. Comes with documentation and schematics, plus additional schematics to build add-on video demodulator board.

92A028 **$14.95 each**

MINIATURE PINHOLE CAMERA WITH AUDIO!!!



Works with any monochrome VCR or monitor. This ultra-compact video camera measures 1-3/16" square by 9/16" thick, and has a 1/16" pinhole lens with 420 horizontal lines of resolution at 0.3 lux low light sensitivity. Has 3.7mm lens for wide field of view. Comes prewired and ready for hook-up. Indludes electret mike, camera board and prewired audio and video outputs with RCA plugs on the end. Camera shown actual size. 12VDC power supply included.

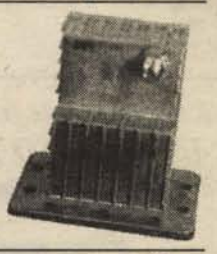
97V001 **$159.00 each**

14-DAY PROGRAMMABLE TIMER

Originally used to control a satellite receiver through its IR port. Time on/off for eight distinct events. Modify it for your needs or dismantle it for its parts. Programmable with a 2732 EPROM in a removable "personality" module,the unit may be modified to control any IR device through its IR port. Contains Z80 CPU, clock display and associated parts. Operates from 9VDC 500 mA wall transformer which is included.

92V014 **$9.95 each**

MINIATURE C-BAND LNB



Low-noise block converter. Better than 40°K noise temperature. Spec sheet included.

94G001 **$49.95**

ASTEC UM1285 RF MODULATOR

With audio. Channel 3 or 4 switchable. Runs on 6 to 15 VDC (internally regulated). Spec sheet included.

92V017 **$4.95 each**

BOOM MIKE

Electret condenser type. This versatile microphone may be wired for handy-talkie, sound card, telephone, base station, aircraft radio, CB radio, motorcycle intercom, etc. An earphone or miniature speaker may be installed in either or both muffs. The microphone unit can be easily removed and installed on another headset or helmet.

92A001 **$4.95 each**

TELEPHONE INTERCONNECT KIT

All components needed to convert the Boom MIke into a substitute for your telephone handset, including earphone, schematic and modular plug. (Boom Mike, 92A001, not included.)

92A004 **$9.95 each**

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COMPUTER HARDWARE *cont.*

WHOLESALE COMPUTERS & electronics confidential source list of overseas suppliers. This list is used by USA companies to purchase computers, memory, hard drives, copiers, cell phones, CATV, audio/video, components, and lots more. Have you ever wondered where it all comes from? Easy to order small or large quantities COD. Yes, they speak English. Incredible, pay pennies on the dollar. Send $19 to ADV, PO Box 440, Middlefield, CT 06455. "Start your own business."

PLASMA DISPLAY, NEW Lucas Deeco M220 text terminal display, 512x256, with 110VAC PS and controller in MILITARY case, $75 each. DAN 415-388-0838, Fax 415-388-9178. E-Mail: rf-ent@worldnet.att.net PO BOX 99, Mill Valley, CA 94942.

19" SVGA color monitor with 2 meg PCI card, 1024x768 with Windows drivers, includes all cables. Ready for plug and play, clean with good color. Atlanta, GA 404-256-4278. Visa accepted. $650 plus shipping.

SUPER VGA monitor $100, 486 computer, monitor $550. 686 computer, monitor $1,200. EGA, CGA monitor $50, $30, HP plotter 7475 $100, HP 7595B D size plotter $500, HP plotter 7550A $125. 386 computer $150, 286 computer $50, Epson printer $30, XT computer $30, HP Think Jet printer $40. HP Paint Jet 3630A $100. Much more. Call 714-827-7345.

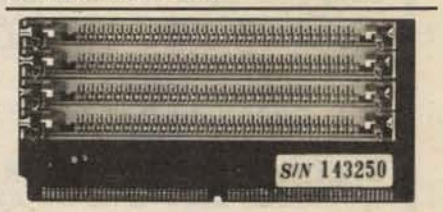
MILLIONS IN scrap gold are about to hit the market in the form of old computer junk. I'm making a bundle recycling this material and you can join me. Call 24-hour message: 603-645-4776.

SIMM 1, 2, 4, 8, 16, 32 meg: All are brand new. 1 meg 30 pin 70ns/60ns $10/$12, 4 meg 30 pin 70ns/60ns $27/$29, 4 meg 72 pin 70ns/60ns $27/$29, 8 meg 72 pin 70ns/60ns $49/$52, 16 meg 72 pin 70ns/60ns $79/$83, 32 meg 72 pin 70ns/60ns $145/$149. All SIMM modules available. 1 yr. warranty. Call Yub Sung, 603-893-5866, Salem NH for current price/availability.

ZSORT. SORT huge files fast. Disk $5. Manual $10. Box 12238, Lexington, KY 40581-2238.

MACINTOSH SYSTEMS repairs, parts and peripherals. Low prices on new, refurb, and used Macs and peripherals and all Mac parts. Repairs of whole units or repair or exchange of parts. Mac Shack 716-377-9230, FAX 716-377-9573. Visa/MC accepted. www.vivanet.com/~macshack

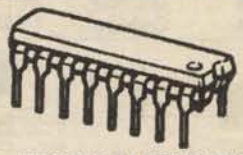
DEC EQUIPMENT WANTED!!! We are buying DEC systems, boards, terminals, drives and peripherals. Also Scientific Micro Systems (SMS), DSD, Datability, Dilog, other DEC compatibles, and Computer Output Microfilm (COM) units. Please call for a quote or fax us your equipment list. We buy, sell, and trade. **KEYWAYS, INC.,** 513-847-2300 OR fax 513-847-2350.



IBM SIMM converters. 4x30P/1x72P $9.95. 2x72P/1x72P $14.95. 4x30P/1x30P $19.95. Price Breakers 360-837-3042. Fax 360-837-2057.

LAN TESTER. Darkstar D510 Universal LAN Network cable tester. Test thinnet, 10BaseT, Tolken Ring cables, terminators, presence of LAN traffic. Activate hub, MAU ports. Includes remote loopback. $595 list, asking $340. Joe Heck, 35 Arrowhead Road, Wrentham, MA 02093. 508-384-8172.

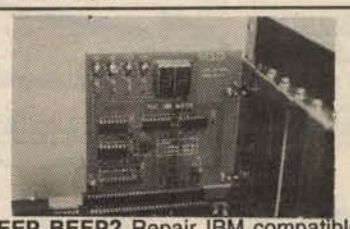
COMPUTER BOOKS, parts, cables, and misc. below wholesale. Great for Computer Swap meets, hamfests, flee markets. For free catalog write: Computer News, PO Box 50127, Casper, WY 82605.



WANTED: EXCESS ELECTRONIC INVENTORIES, ICs, MEMORY, EPROMs, PALs, LEDs, CIRCUIT BOARDS, DIODES, AND TRANSISTORS. CALL ACTIVE MICRO, 310-494-4851 OR FAX 310-494-4913.

IBM 2-meg, 27-pin SIMMs $9.95 each. 640 meg full height SCSI hard drives (new) $99 each. 80 meg half height SCSI hard drives (Quantum) $39.95 each. UltaStor 34F VLB SCSI controller card and software $49.95 each. AlMet Recycle & Surplus 904-673-1281.

STEPPER DRIVERS & CAM SOFTWARE: microstepping full/2/3/4/5/6/7/8. 3 & 6 amp starting at $117. Software: Plotcam motion $149. Z-trace isolation (toolpath from PCB gerber) $299. heater@greater.net MSG/FAX 407-452-7197 407-459-2729 http://mall.greater.net/mall/ddt



BEEP BEEP? Repair IBM compatible PCs with the "POST CODE MASTER" plug-in card. Shows result of Power On Self Test performed by all major BIOSs. Manual reveals their meaning and also explains those cryptic beep codes, $59. **MSD**, 4100 Moorpark Ave. #104, San Jose, CA 95117. 408-296-4000, Fax: 408-296-5877.

CHAFFIN ELECTRONICS INC. Call us for all your IC needs. Let us save you $$$$. Call Sales 614-574-4456, Sales 614-574-6906, FAX 614-574-2124.

TRS-80 MODELS 1, 3, 4, 100 Pocket Computer, COCO. Hardware, software, repair/replacement parts, accessories. #10 SASE for list. Pete Bumgardner, 100-D W. Falls St., Kings Mountain, NC 28086. 704-730-0893.

SONY/AMIGA MULTISCANS 15", 0.26DP 15.7 thru 36KHz CGA thru SVGA (1024 x 768 I). $175. Generic VGA color monitors from $125. Expert Sony repair, parts available. **Dealer discounts.** Refurbished guaranteed. Pikul & Assoc., 101 Glenfield Dr., Festus, MO 63028. 314-937-0335.

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Many of our kits are available completely built!

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Boost your microphones output up to line level!

Plug your mic into our AP-1 and drive your amp. to full capacity. Connect an AP-1 to a pair of amplified speakers, plug your mic in and you have an instant PA system. Requires 6 to 12v DC Size: 1.75" X 1"

AP-1 KIT **$9.95**

TV NOTCH FILTERS FOR CHANNELS 2 thru 22 ONLY

Our TV filters eliminate unwanted TV channels or interference that alters both sound and video with a beep beep beep. Works on cable channels (2 thru 22) only.

NOTE: All TV Filter Kits are sold for educational purposes only. You must obtain permission from your local cable company before using these filters on your cable system.

DF-222 KIT **$14.95**

3-1/2 DIGIT LCD THERMOMETER WITH DUAL TEMPERATURE PROBES

MANY PRACTICAL APPLICATIONS:

- Indoor / Outdoor temperature.
- Temperature of electronic equipment vs room temperature.
- Furnace or Air Conditioner efficiency (return air) vs (output air).
- Temperature inside car / outside car
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SIZE: 2 3/4"W x 1 5/8"H x 1"D

LCD-T1 KIT **$34.95**
LCD-T1C CABINET **$9.95**

STROBE LIGHT

Do you need an attention getter, warning light,or flashing light for model airplanes? Then this kit is for you. Use it as an emergency light for your auto, radio tower, even use it on your bicycle. Has a variable flash rate.Power requirement 6 or 12v DC. Size 3.5"x1.9"

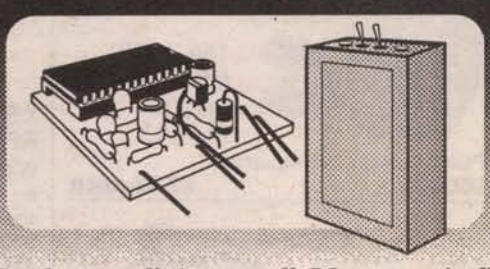
ST-1 KIT **$11.95**

Read the code from any INFRARED Device

- Complete with Software for any 80386 or 80486 base machine, operating on DOS 3.3 or higher.
- Sampled data can be saved to disk for instant comparison & analysis.
- Zoom in on and view any 8 millisecond portion.

TIR-1 KIT **$89.95**

AUTO CALL ID'ER



Send your call sign or call CQ automatically with the push of a button.

Change your message as often as you like.

The AUTO CALL enables you to electronically store a 20 second message of your choice.

- (Your call sign or call CQ, for instance) and send it with the push of a button. Change your message as often as you like.
- Your message is stored in on board non-volatile memory cells. providing ***zero-power*** data storage. This is a high-quality voice recording and playback unit.

RX-1 KIT **$49.95**
RX-1C SIZE: 1"H x 2.4"W x 3.8"D CABINET **$12.95**

SUPER SNOOPER BIG EAR

Listen through walls, hear conversations across the room. Add a parabolic reflector and hear blocks away. The BIG EAR can be hidden about anywhere. Makes an ultra sensitive intercom. Can be used as a 1.5W AMP. We supply a mini-electret mike in the kit. Power requirement 6 to12v DC. SIZE:1.75"x 1"

AA-1 BUILT **$29.95** KIT **$10.95**

PHONE TRANSMITTER

Small but mighty,it fits anywhere. Phone line powered, never needs batteries. Transmits both sides of a phone conversation loud and clear, wireless, to any FM radio at great distances. Variable tunes from 70MHz to 130MHz FM. You can also use it as a speaker phone. SIZE:1.25" x .6".

TEL-B1 KIT **$12.95**

Sweet 16 TONE DECODER

Sweet 16 tone decoder operates great over phone lines, radios or scanners.

- 16 TTL Level Outputs
- DTMF Decoder Decodes 16 different touch tones using the phone, radios, or scanners.
- One relay & driver circuit on board.
- 9v battery powered.Size: 2 3/4" x 2 1/8"

TT-16 KIT **$34.95**

This Manual contains schematics, parts lists & P.C. board layouts for many of the Rainbow Kits. Use your own parts to construct our kits.

KIT BOOK $14.95
$9.95 with the purchase of any kit.

WIRELESS FM MICROPHONE

Small but mighty this little jewel will out perform most units many times its price. It really stomps out a signal. The WM-2 kit is a buffered wireless mike that operates from 80MHz to 120MHz FM, the frequency of any broadcast FM radio. Includes a mini-electret mike. 6 to 12v DC. SIZE: 1.25" x 1"

WM-2 KIT **$14.95**

MICRO-MINIATURE WIRELESS MIKE

So small you could hide this one on some real bugs! It's the smallest we've ever seen. With it's super sensitive mike it transmits a whisper or a room of conversation to an FM radio, tunable from 88 to 108MHz FM. With a proper antenna it transmits about 1/2 mile. The kit is made with surface mounted parts, we have already mounted these parts. You install the leaded parts. Power requirement 6 to 12v DC. Size .35"x.9"

MMWM5 KIT **$34.95**

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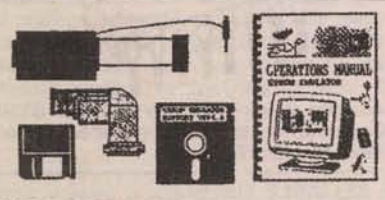


EPROM EMULATORS. Test your code without disconnecting equipment. All ICs mounted in sockets. MODEL-32 (2764-27256) $109. MODEL-64 (2764-27512) $129. **PRO-SERIES.** Includes battery back-up and real time link for single byte changes. PRO-128 (2764-27010) only $199. PRO-512 (2764-27040) for $259. $5 shipping. Visa. Logical Design Tools, Inc. 512-888-4535. Internet. http://www2.interconnect.net/ldti/hom.htm

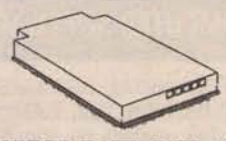
HP 1611A logic analyzer $300. Kaypro 10 computer $200. Bob 408-429-6888.

MONITOR SPECIAL: VGA $110, EGA $65, CGA $55. 90 days guaranteed. Call TFD Services 714-542-1037.

HEWLETT PACKARD plotters. Refurb with 60-day warranty. HP 7475A $149, HP 7550A $239. Both do up to 11 x 17 drawings, and work with all popular CAD and graphics programs. Comes with pens too! Larger also available. Stewart & Associates, 1-800-704-6500.

PLOTTERS: HP 7580B drafting plotter (sizes A-D) $1,300. **HP 7586B** (sizes A-E) $1,850. **HP 7595A** DraftMaster I (sizes A-E) $2,000. **HP 7475A** $220. **HP 7550A** $350. Excellent condition, warranty. Pepper Systems, 214-353-0257 (FAX 214-902-9511).

FROM SOURCE: motherboards with IDE-I/O controller on board, CPUs, mice, CD-ROMs, video controller, and other parts. Rebuilt systems. Phone/Fax 630-789-8393.



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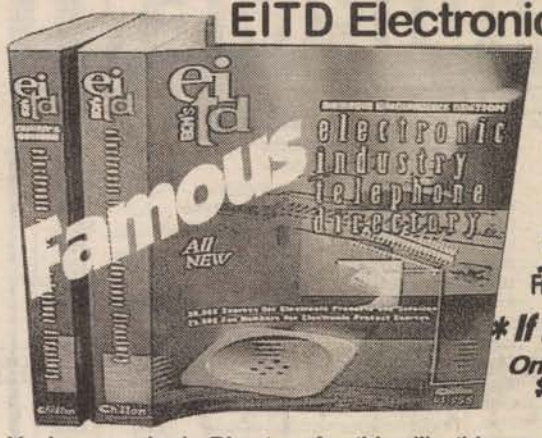

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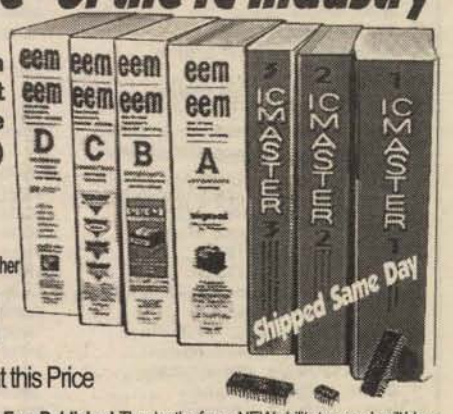

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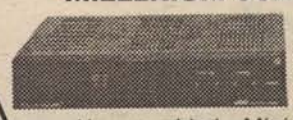

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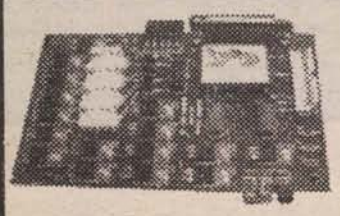

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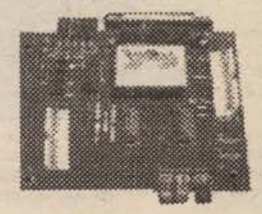

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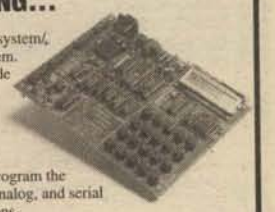

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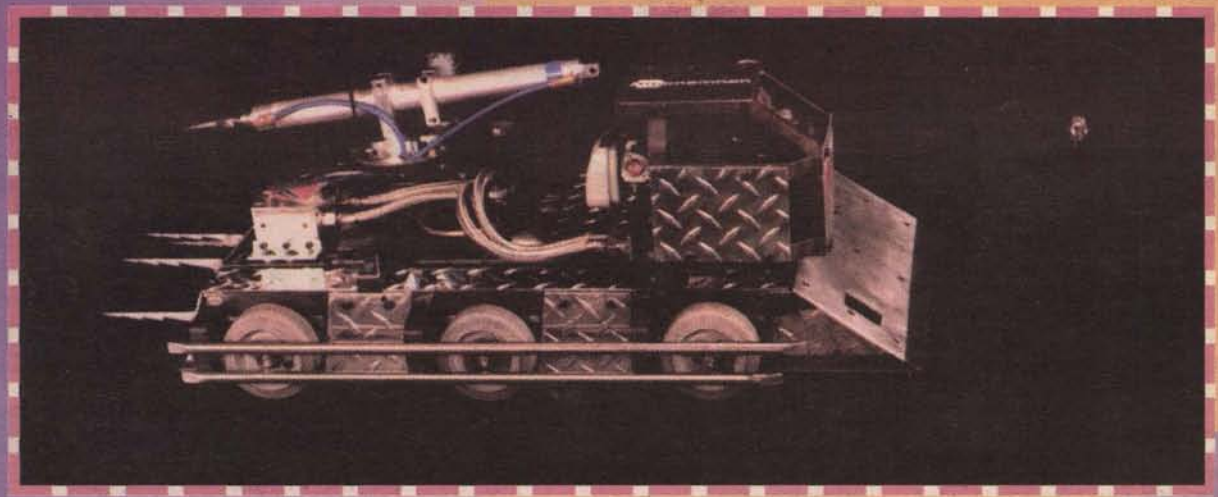
The Agamemnon:

Construction of the 1996 Robot Wars Middleweight Winner

by Dan Danknick



Introduction

"Fall back, let's see if you disabled him," the judge yelled over the screaming crowd.

As I eased back on my joystick control, a 100 lb. machine of destruction glided away from its target of wood and steel. My opponent furiously moved his controls hoping to coax one last spasm from his robot. Nothing.

Okay, looks like you win. Take your victory spin in the middle." And so ended my first one-on-one battle at Robot Wars 1996. The remainder of the weekend was to follow the same path, ultimately taking me to final victory in two divisions. It was a satisfying conclusion to 13 months of work and a $3,000.00 materials bill.

Step back two years to August 1994. I've convinced three friends to take a road trip to San Francisco to watch the very first Robot Wars competition. The all-night drive became more appealing when I supplied "event" T-shirts and three cases of soda, Jolt included.

"I have no idea what this will be like, I only read a one-page description of it. But the picture did have a chainsaw bolted to an RC car. Don't blame me if it stinks," I said to my comrades as we cruised up Interstate 5. But it didn't stink, and we left with hoarse voices from cheering all day.

Marc Thorpe, Robot Wars is a battle of skill, engineering, and luck. Robots (technically RC vehicles) compete head-to-head in an inch-thick Plexiglas shielded arena, attempting to disable each other to the entertainment of the crowd. In short, it's a bloodsport.

Entries from all over the world converge for a day of mayhem, wielding their cutting saws and pneumatic punches. Entries are grouped according to weight: featherweight (5-25 lb.); lightweight (26-50 lb.); middleweight (51-100 lb.); and heavyweight (101-170 lb.)

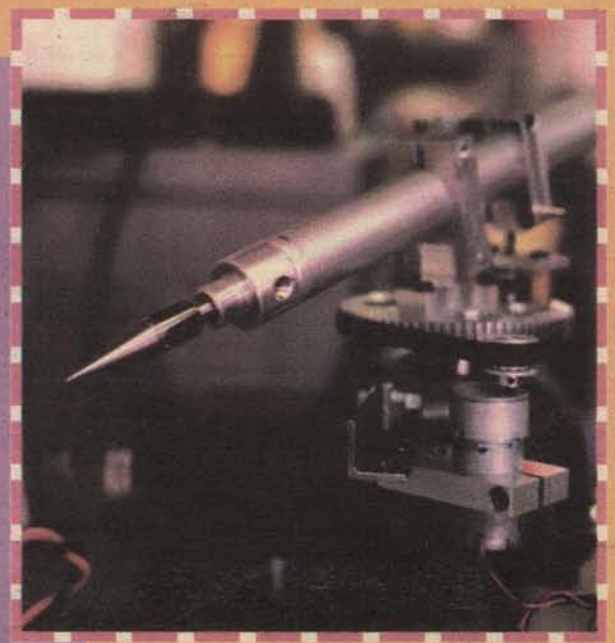
To protect the audience, weapons involving flames, explosives, liquids, electrical discharges, untethered projectiles, and expanding foams are prohibited. For fairness, so is radio jamming. Entries are subjected to a weigh-in and safety inspection before competing. Beyond the stated rules, the field of invention is wide open.

Birth of the Agamemnon

I began my design by picking a weight class. Middleweight seemed the most feasible with my resources, but still possessed enough weight budget to get some good mechanics in place.

I spent a week examining the year-two contestants in my chosen class: how could I defend against them and how could I disable them?

From the two lists a common thread emerged: low center of gravity and high torque

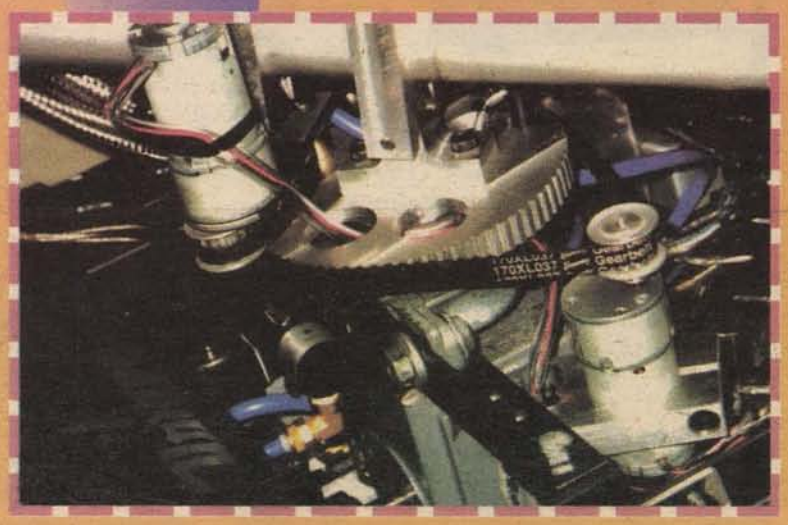


Year two was better with improved designs, more entrants and a second day of steel shattering battles. The enormous growth of the event in only 12 months was the final goad that propelled me into the contestant's circle.

A year of late-night machining, welding sunburns, and low-bank balances was ahead of me, but as each month passed, the fun I was having far outweighed the inconveniences.

Event History

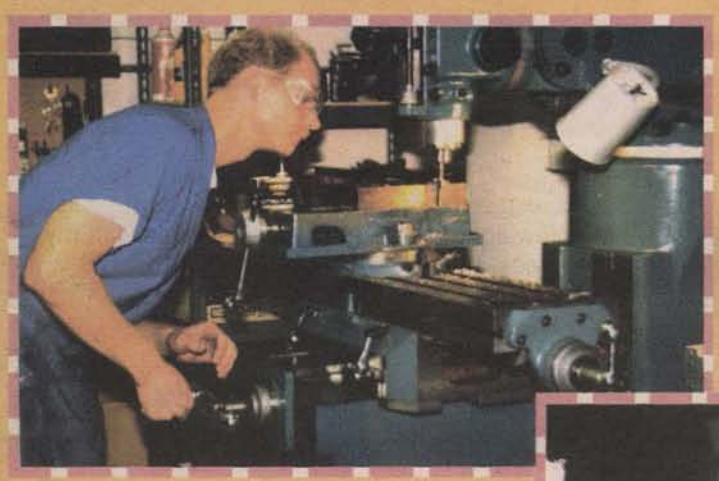
Created by ex-ILM employee



drive system. I added extreme reliability to this, as well as over engineering for a good margin of safety. I might not win, but I would never fall apart.

The first idea was to fab the frame from square tube aluminum stock. A preliminary joint test showed it unsuitable for high acceleration loads (like, say, a 20 MPH side collision with a 100 lb. robot). I moved to mild steel and bought a MIG welder to put it together.

The frame is designed as two squares, one rising above the other. A non-rigid coupling of the two allows the power transmission drive to be isolated from the hard point weapon mounts, the idea being that getting the weapons-frame bashed up wouldn't throw the driveline out of alignment.

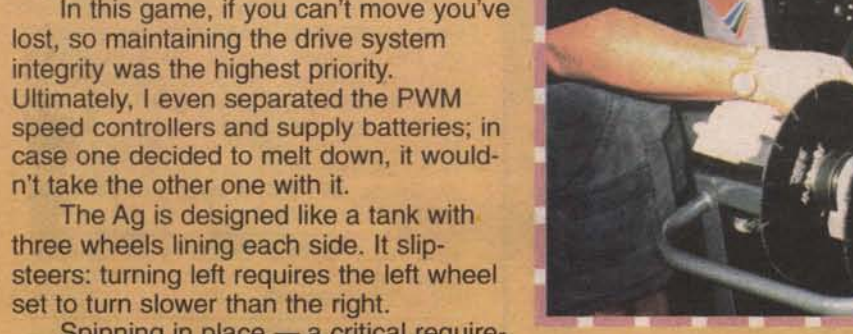


In this game, if you can't move you've lost, so maintaining the drive system integrity was the highest priority. Ultimately, I even separated the PWM speed controllers and supply batteries; in case one decided to melt down, it wouldn't take the other one with it.

The Ag is designed like a tank with three wheels lining each side. It slip-steers: turning left requires the left wheel set to turn slower than the right.

Spinning in place — a critical requirement for getting out of a corner — is accomplished by running the wheels in opposite rotation.

The drive motors are surplus permanent magnet DC types running at 12V. Variable speed forward and reverse is supplied by off-the-shelf H-bridge speed controllers designed for electric RC cars. Power is supplied by sealed lead-acid gel-cell batteries.



In the interest of weight, the size of the batteries was minimized to supply only enough power for each five minute battle. This required the purchase of additional sets to compete during the eight-hour recharge time.

The 1/6th horsepower from each motor is coupled to a 30:1 worm gear speed reducer and then to a synchronous belt drive connecting the wheels. To improve efficiency, I cut away the shaft dust seals and drained the gear oil from the reducers. It made a huge difference.

Rubber caster wheels of four inch diameter were specifically chosen for high traction on the smooth asphalt of the arena floor. (I snuck out to feel it before we left in '95).

The final speed is six ft/sec with enough torque to tow my Isuzu Rodeo down the street.

The base finally came together at the end of January after six months of design and engineering. It was as strong as I could design and I was satisfied.

TEAM DELTA 1997
(L to R)
Greg Willingham, Dan Danknick, Dave Johnson, and Mike Bell.

The Fun Stuff

All along, I disciplined myself: build a reliable drive system before you start on the weapons. The coolest weapon in the world would still idle if its mobility system was inoperative. But in the back of my mind I was churning over ideas.

The first weapon I envisioned was a couple of saw blades mounted in front of the robot. I figured this could inflict only moderate damage, but would be really exciting to watch.

Just looking at two unguarded blades boldly thrusting in front of a mobile base was exciting, too. I purchased a professional model gas powered weed whacker with a detachable gas tank.

Because it would operate in any orientation, it was easily adapted to drive a horizontal shaft. A heavier duty belt drive links the engine to the cutting "head," a full foot in front of the vehicle.

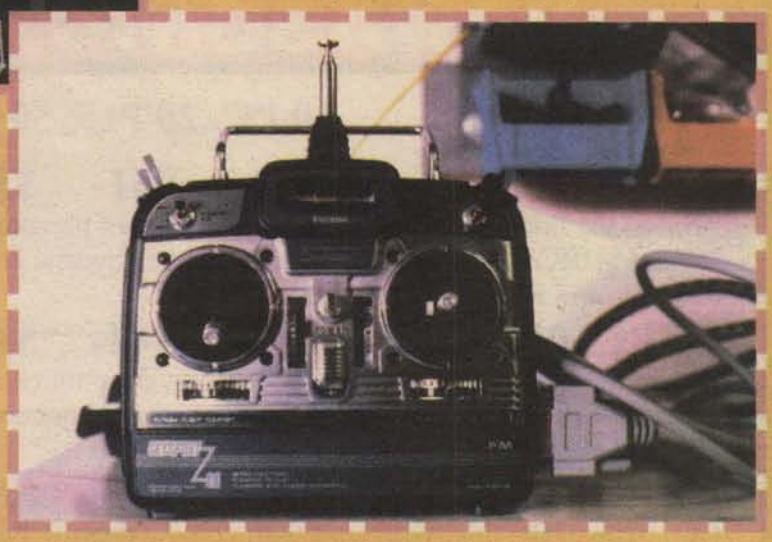
The entire assembly is mounted on heavy duty equipment slides salvaged from a 19" rack-mount tape drive. The slides allow the engine/cutter to recoil eight inches over the top of the base, to absorb the shock of contacting another robot.

A variable tension spring maintains blade pressure on the target while compensating for refined driving skills should the target move away in escape. Since the blades would encounter unknown materials, not just any could be used with success. I special-ordered fire department emergency entry blades designed for cutting into cars and roll-up steel doors with handheld equipment.

Though impressive, they turned out to be far too heavy for this application. So I settled on a carbide grit-edged steel model designed for cutting through iron pipe.

The gasoline tank was encased in a durable aluminum box and set into a pocket in the aft interior of the frame, away from the engine. Fuel lines were routed through stainless steel braid for protection. The safety engineers at the event practically cheered when they saw this, with the design ultimately becoming a rule beginning in this year's competition.

Around this time, I designed a web site to show off this robot project to the Internet community. There were other Robot Wars pages already on the net, but their content was mostly post facto, detailing the competition and how they fared. Nobody dared post design plans in advance, apparently fearing that a crafty opponent would exploit them to his advantage. (I soon learned that the real reason was that many of the contestants didn't start building their robots until a few weeks before the event.)



This didn't worry me. "I'm smarter than all of you and my team is top-notch," I bragged to myself. My monthly "status reports," including pictures and descriptions, eventually became quite popular.

I still had 20 pounds. of weight budget to

blow, so more weapons were devised. An array of nine tube-launched rockets was designed and tested with great success. I soldered copper fins onto copper pipe and tethered them with small spools of very light steel cable.

When a tiny solid propellant model engine was electrically ignited, the rocket zoomed through a 14" piece of square tube steel, eventually getting yanked to a stop 30 feet downrange by the tether. I figured it would be a real audience pleaser to see all the rockets fired sequentially. For the finale, I planned to eject the launch tube array onto the floor after the sequence. It was looking real good until I received E-Mail from an Australian fan: "Aren't those rockets a violation of the 'no explosives' rule?" Fear gripped my heart. Then an E-Mail reply from Robot Wars central closed the door on this weapon, the Fire Marshall wouldn't permit such a device indoors at the event.

I spent an afternoon working through the kinetic energy equations of a spring-loaded weapon system. The idea was that such a weapon was loaded and locked in the pit area, where energy was abundant.

One design was to strap an ice axe to a garage door spring that was bent in half. It was a one-shot weapon to be released with careful timing.

A quick trip to the hardware store yielded that garage door-type springs aren't designed to be bent in a U shape, as they deform quite easily. I managed to hide the evidence and return home.

The next design explored the possibility of a metal spear gun using a long compression spring. But even the stiffest and longest stock springs would impart too little velocity to a tethered pike.

I switched to pneumatics. After a month of reading and researching I came up with a design: Mount a 12" double-ended air cylinder atop a custom-built pan and tilt rig; tip the shaft with a titanium barb (ground from the bearing shaft of a bicycle bottom bracket). A spun aluminum tank stores 1000 PSI nitrogen on board using a light paintball CO2 regulator to step it down to 150 PSI. This lower pressure supply is switched by 12 VDC air valves into both ends of the cylinder.

A BASIC Stamp clone from Scott Edwards Electronics runs the control firmware, which I wrote to decode the signal from the RC receiver. Using a laptop to download new software in the field, the operation of the "punch" can be changed from rapid strikes to powerful thrusts at the expense of higher gas consumption. The controller also drives a small PWM unit to control acceleration curves on the pan and tilt motors, giving fine control in close while quickly accomplishing larger targeting swings.

One important facet of event judging involves breaking a tie between two robots. The accepted solution is to use a dB meter to measure audience cheer for the favorite. I wanted to capitalize on this so I installed a small CCD camera in the nose of the Ag, returning a live video feedback over a radio link. Now, not only could I display the battle robot's point-of-view to the audience on the huge TV monitor array (a first), but I could get lined up better for high speed ramming runs against an enemy.

A brief E-Mail to Virtual iO proved fruitful; they were more than happy to provide me with all the pairs of virtual reality goggles that I wanted. I had my first sponsor and was the only contestant to wear a pair of VR goggles while driving my robot. Being a software engineer, I'd had precious little experience with last minute system integration issues. So it was to my complete surprise that during the all-nighter before the event, the vibrations from the gas engine unscrewed the tuning slugs from the transmitter core, detuning the circuit. The hastily re- tuned circuit ran at 50% during the competition, but it was sufficient.

Conclusion

In three head-to-head and one melee battle (six at once; pick a target), I sustained very little damage: a broken aluminum weld (not critical), a cotton net jammed the front blades (easily repaired), and a scratched American flag sticker. I've retired the Ag to a shelf in the garage.

I'm designing a completely new robot, the Alexander, for the August 1997 battle. The preliminary specifications call for six times the drive power (double the torque, triple the speed);. three completely new weapons are designed, with a total power output of over 2.5 horsepower.

My machining skills have improved significantly, allowing me to use advanced technology components in the design; solid plastic bearings from Igus are a good example.

The studies of metallurgy and materials science have given me a greater understanding of steel and aluminum compositions. Many structural elements on the Alexander have been made from a hard aluminum alloy, 64% lighter than steel.

I post monthly reports on my progress to the web page, in addition to providing a number of resources to the amateur robot builder. I also list other Robot Wars web sites; there are many exciting designs out there! If you stop by http://www.teamdelta.com be sure to drop me a note and say "Hi." **NV**

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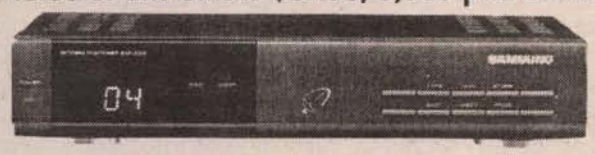

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HP 2225A GPIB PRINTER	$ 99.00
HONEYWELL 1858 VISICORDER	$ 4000.00
HP 4342A Q METER	$ 2400.00
STANFORD RESEARCH SR510 LOCK IN	$ 1000.00
TEKTRONIX OF150 OTDR	$ 4500.00
TEKTRONIX TM504 OR TM503	$ 200.00
HP 3497A DATA ACQ. MAINFRAME	$ 1200.00
HP 44421A 20CH MUX FOR 3497A	$ 300.00
HP 44428A 16CH ACTUATOR	$ 300.00
TEK 577D2/177 CURVE TRACER WITH STANDARD INPUT	$ 2200.00
AC/DC EL750B ELECTRONIC LOAD, 750 WATT	$ 995.00

THESE INSTRUMENTS ARE IN EXCELLENT CONDITION. WE GUARANTEE THEY WILL MEET MFRS SPECIFICATIONS, AND ARE SUPPLIED WITH A MANUAL, POWER CORD AND 90 DAY WARRANTY

PHONE 800-442-5835 OR 415-969-1142

FAX 415-969-0334

EMAIL TESTLAB2@IX.NETCOM.COM

WEB http://www.testlabco.com

TEST LAB COMPANY

1066 LINDA VISTA AVENUE

MOUNTAIN VIEW, CA 94043

Write in 213 on Reader Service Card.

Events

CALENDAR

The Events Calendar is a free service limited to electronic events such as computer shows, hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days prior to the event. Include your flyer, estimated attendance, name of the person to contact, and phone number.

Complimentary issues are available upon request for distribution to your attendees. A street address for UPS is required.

While we strive for accuracy in our calendar, we can not be responsible for errors or cancellations. The information contained in this column is for the use of the readers of *Nuts & Volts* and may not be republished in any form without the written permission of T & L Publications, Inc.

All listing information should be sent to:
Nuts & Volts Magazine
Events Calendar
430 Princeland Court
Corona, CA 91719
Phone 909-371-8497
Fax 909-371-3052
E-mail events@nutsvolts.com

MARCH 1997

MARCH 1

AL - TUSCALOOSA - Black Warrior Swapfest. Kelly Bruce 205-339-7882
CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052
GA - ATHENS - Hamfest. NE Georgia Bubba Net. James Daniel 706-742-2777
MI - LIVONIA - Super Computer Sales. Livonia Elks Lodge Hall, 31117 Plymouth Rd. 10am-3pm. Computers & You 313-283-1754
MD - FREDERICK - Computer Show. Frederick Fairgrounds. MarketPro 301-984-0880
NJ - ABSECON - Springfest '97 Hamfest. Holy Spirit High School. Shore Points ARC 609-653-1987
NJ - PARSIPPANY - Hamfest. PAL Building. Split Rock/West Morris Radio Clubs. Bernie 201-584-5399
OK - ELK CITY - ARRL Hamfest. West Central OK ARC. Earl Bottom 405-473-2572
TN - CLEVELAND - Hamfest. Ocoee ARS. Alan Pinney 423–478-1141

MARCH 1-2

CA - VALLEJO - Computer Show & Sale. Solano Co. Fgrds. MarketPro 415-456-6730
FL - FT. LAUDERDALE - Computer Show. War Memorial Auditorium. MarketPro 301-984-0880 xt15
GA - COLUMBUS - Southeastern Computer Show. Historic Iron Works Conv. & Trade Center. Sat: 9am-5pm, Sun: 10am-4pm. Hugh Greenlee 770-455-8997
IN - FT. WAYNE - Computer Show. Allen County Fairgrounds. MarketPro 301-984-0880 xt15
NJ - FAIRFIELD - Computer Show. Fairfield Radisson. 9:30am-4pm. MarketPro 201-825-2229
OH - CINCINNATI - Computer Fair. Cincinnati Gardens. Sat: 10am-5pm, Sun: 10am-3pm. Trade Show Productions 937-263-3378
PA - HARRISBURG - Computer Show. Farm Show Complex. MarketPro 301-984-0880 xt15
VA - NORFOLK - Computer Show. Norfolk Scope. MarketPro 301-984-0880 xt15
WV - CHARLESTON - Computer Show. Charleston Convention Center. MarketPro 301-984-0880

MARCH 2

CA - LIVERMORE - Swapmeet. Las Positas College. Noel Anklam 510-447-3857
CA - SAN DIEGO - Computer Show & Sale. Scottish Rite Center. 10am-5pm. MarketPro 415-456-6730
CT - BRISTOL - Hamfest. Insurance City Repeater Club. Pete Brunelli 860-620-0176
GA - NORCROSS - Computer Show & Sale. Northeast Atlanta Hilton, 5993 Peachtree Industrial Blvd. Narisaam 770-663-0983
MA - SWANSEA - Computer Show. Venus DeMilo. 9:30am-2:30pm. Northern Computer Shows 508-744-8440
MI - GRAND RAPIDS - Super Computer Sales. Crowne Plaza, 5700 28th St. SE. 10am-4pm. Computers & You 313-283-1754
PA - TREVOSE - Photographic Swap/Shop Show. Radisson Hotel. 10am-3pm. OMM Productions 610-527-5903
VA - ANNANDALE - Computer Show. Northern Virginia Community College. MarketPro 301-984-0880

MARCH 7-8

ME - LEWISTON - State Convention. Dave Blethen 207-353-6433

MARCH 7-8-9

LA - LAFAYETTE - ARRL Hamfest. Acadiana ARA. L. Al Oubre 318-367-3901
NE - NORFOLK - State Convention. Rick Kropf 402-371-7684

MARCH 8

CA - FONTANA - Inland Empire ARC Amateur & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves.
CA - OAKLAND - Robert Austin Computer Show. Convention Center. 1-800-346-0100
CA - SACRAMENTO - Computer Show & Sale. Cal Expo. MarketPro 415-456-6730
FL - ENGLEWOOD - HamCom '97. Tringali Community Center, SR 776 Englewood East. 8am-3pm. George Shreve 941-697-3445
IN - INDIANAPOLIS - AGI Computer Fair. Indianapolis Events Center, 3655 E. Raymond St. 10am-4pm. 317-299-8827
KY - HAZARD - ARRL Hamfest. Kentucky Mountains ARC. 8am-2pm. John Farler 606-436-5354
MI - JACKSON - Super Computer Sales. Jackson Co. Fairgrounds, 200 W. Ganson. 10am-3pm. Computers & You 313-283-1754
MI - ROSEVILLE - Amateur Radio Open House. Macomb Mall. David Herrington 810-465-2797
NH - PORTSMOUTH - Computer Show. Frank Jones Center. 10am-3:30pm. Northern Computer Shows 508-744-8440
NY - TROY - Computer Show. Troy Armory. 9:30am-4pm. MarketPro 201-825-2229
WA - PUYALLUP - Electronics Show & Fleamarket. Pavilion Exhibition Hall, Western Washington Fairgrounds. 206-631-3756

MARCH 8-9

FL - ORLANDO - Computer Show. Orlando Expo Center. MarketPro 301-984-0880 xt15
GA - KENNESAW - Computer Show. I-75 Exit 116, go W. on Barrett Pkwy. to Hwy. 41, turn right, go to 2nd traffic light; we're on the right next to "Cowboys." GA Mountain Productions 706-838-4827
MD - NEW CARROLLTON - Computer Show. Ramada Conference & Exhibition Center. MarketPro 301-984-0880
NC - CHARLOTTE - Hamfest & Computer Fair. 25 E. Independence Blvd., Hwy 74 E. Sat. 9am-5pm, Sun. 9am-2pm. 704-948-7373
PA - GREENSBURG - Computer Show. Greengate Mall Expo Center. MarketPro 301-984-0880
PA - KING OF PRUSSIA - Computer Show. Valley Forge Conv. Ctr. MarketPro 301-984-0880 xt15
VA - RICHMOND - Computer Show. The Showplace. MarketPro 301-984-0880 xt15

MARCH 9

CA - STOCKTON - Computer Show & Sale. Civic Auditorium. 10am-5pm. MarketPro 415-456-6730
IN - INDIANAPOLIS - Hamfest. Morgan Co. Repeater Assn Brian Elliott 317-342-7236
IN - INDIANAPOLIS - Hamfest & Computer Show. State Fairgrounds, East Pavilion Bldg. 317-996-3782
ME - AUGUSTA - Computer Show. Augusta Armory. 10am-3:30pm. Northern Computer Shows 508-744-8440
MI - KALAMAZOO - Super Computer Sales. Wings Stadium, 3600 Vanrick Dr. 10am-4pm. Computers & You 313-283-1754
NY - LINDENHURST - ARRL Hamfest. Great South Bay ARC. Walter Wenzel 516-957-0218
NY - POUGHKEEPSIE - Computer Show. Mid-Hudson Civic Center. 9:30am-4pm. MarketPro 201-825-2229
OH - CONNEAUT - Ham/Computerfest. Human Resource Center, 327 Mill St. Jack Marttila 216-593-3353
WI - WAUKESHA - Swapfest & Computer Expo. County Expo Center, N1 W24848 Northview Rd. 8am-2pm. SEWFARS 414-650-0724

MARCH 15

CA - ARMONA - Hams & Hackers Swap Meet. Hanford Fraternal Hall, 10th Ave. @ Florinda, Hanford. Doug 209-582-0949
CA - SAN FRANCISCO - Computer Show & Sale. Pier 29 on Embarcadero. MarketPro 415-456-6730
CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052
CA - SANTA ROSA - Computer Show & Sale. Sonoma Co. Fairgrounds. MarketPro 415-456-6730
FL - FORT LAUDERDALE - Computer Show & Sale. Holiday Inn West, 5100 N. State Road 7. Narisaam 770-663-0983
GA - MARIETTA - ARRL Hamfest. Jim Miller Park. 9am-4pm. Margaret Durham 770-977-4405
MI - MARSHALL - Hamfest. Marshall High School. 8am-3pm. Wes Chaney 616-979-3433
MI - TAYLOR - Super Computer Sales. Democratic Club Hall, 23400 Wick Rd. 10am-3pm. Computers & You 313-283-1754
NH - SALEM - Computer Show. Rockingham Park Race Track. 10am-3:30pm. Northern Computer Shows 508-744-8440
NY - BUFFALO - Computer Show. Hamburg Fairgrounds. 9:30am-4pm. MarketPro 201-825-2229
TN - KNOXVILLE - Hamfest. Kerbela Shrine Temple. 8am-4pm. Paul Baird 423-986-9562
VA - ANNANDALE - Computer Show. Northern Virginia Community College. MarketPro 301-984-0880

MARCH 15-16

FL - TAMPA - Computer Show. Florida State Fairgrounds. MarketPro 301-984-0880 xt15
GA - NORCROSS - Computer Show. North Atlanta Trade Center. MarketPro 301-984-0880 xt15
NY - STONY BROOK - Computer Show. SUNY Stony Brook. 9:30am-4pm. MarketPro 201-825-2229
OK - TULSA - State Convention/Hamfest. 7th & Houston. Maxwell Convention Center. Merlin Griffin 918-622-2277
PA - MONROEVILLE - Computer Show. Pittsburgh Expo Mart. MarketPro 301-984-0880 xt15
TX - MIDLAND - ARRL Hamfest. Midland ARC. Beverley Harwood 915-686-1841

MARCH 16

CA - LANCASTER - Computer Show & Sale. Antelope Valley Fairgrounds. 10am-5pm. MarketPro 415-456-6730
CA - SACRAMENTO - Computer Show & Sale. Scottish Rite Center. 10am-5pm. MarketPro 415-456-6730
IL - STERLING - Hamfest. Sterling High School Field House, 1608 4th Ave. 815-336-2434
FL - WEST PALM BEACH - Computer Show & Sale. Palm Beach Airport Hilton, 150 Australian Ave. Narisaam 770-663-0983
MA - WORCESTER - Computer Show. Crowne Plaza Hotel. 10am-3:30pm. Northern Computer Shows 508-744-8440
MI - MADISON HEIGHTS - Super Computer Sales. UFCW Hall, 876 Horace Brown Dr. 10am-4pm. Computers & You 313-283-1754
NY - ROCHESTER - Computer Show. The Dome Center. 9:30am-4pm. MarketPro 201-825-2229
OH - MAUMEE - Hamfest/Computer Fair. Lucas Co. Recreation Center, 2901 Key St. 8am-3pm. TMRA. Paul Hanslik 419-243-3836
PA - YORK - Springfest. Union Fire & Hose Co., E. Canal Rd., Dover, PA. John H. Shaffer 717-764-4805
WI - JEFFERSON - Hamfest. Jefferson Co. Fairgrounds. Tri County ARC 414-563-6502
WV - CHARLESTON - Hamfest & Computer Show. Jimmie Hewlett 304-768-1142
VA - FREDERICKSBURG - Computer Show. Fredericksburg Armory. MarketPro 301-984-0880
VA - HARRISONBURG - Computer Show. Rockingham Co. Fairgrounds. MarketPro 301-984-0880

MARCH 21-22-23

WI - MILWAUKEE - Computer Show. Milwaukee State Fair. Blue Star Productions 612-788-1901

MARCH 22

CA - FRESNO - Computer Show & Sale. Fresno Fairgrounds. MarketPro 415-456-6730
CA - VENTURA - Computer Show & Sale. Ventura Fairgrounds. MarketPro 415-456-6730
FL - AVON PARK - Hamfest & Computer Show. National Guard Armory, 2500 US Hwy 27 South. 8am-2pm. Clyde Scruggs 941-453-7181
FL - STUART - Hamfest. Martin Co. Fairgrounds, 2616 S. Dixie Hwy. 8am-3pm. Dave Millard 407-288-7100
IL - BRADLEY - Computer Show. Ramada Inn, Rte. 50 N. 9am-3pm. Gary 815-935-1605
MA - ROCKLAND - Computer Show. Sons of Italy. 10am-3:30pm. Northern Computer Shows 508-744-8440
MO - KANSAS CITY - Hambash. Ararat Temple, 5100 Ararat Dr. 8am-2pm. Steve Dowdy 816-941-0620
NJ - WEST ORANGE - Hamfest. West Orange H.S. 600 Pleasant Valley Way. 9am-2pm. Jim Howe 201-402-6066
PA - MECHANICSBURG - Computer Show. Holiday Inn Mechanicsburg. MarketPro 301-984-0880

MARCH 22-23

FL - JACKSONVILLE - Computer Show. Jacksonville Fairgrounds. MarketPro 301-984-0880 xt15
IN - INDIANAPOLIS - Computer Show. Indiana State Fairgrounds. MarketPro 301-984-0880 xt15
IN - NASHVILLE - Computer Show. Nashville Armory. MarketPro 301-984-0880 xt15
NC - CHARLOTTE - Computer Show. The Merchandise Mart. 9:30am-4pm. MarketPro 201-825-2229
NY - WHITE PLAINS - Computer Show. Westchester Co. Center. 9:30am-4pm. MarketPro 201-825-2229
VA - CHANTILLY - Computer Show. Capital Expo Center. MarketPro 301-984-0880
VA - ROANOKE - Computer Show. Roanoke Civic Center. MarketPro 301-984-0880

MARCH 23

CA - MODESTO - Computer Show & Sale. Centre Plaza at Red Lion. 10am-5pm. MarketPro 415-456-6730
CA - OXNARD - Computer Show & Sale. Community Center. 10am-5pm. MarketPro 415-456-6730
CA - VISALIA - Computer Show & Sale. Convention Center. 10am-5pm. MarketPro 415-456-6730
IL - GLEN ELLYN - Computer Show & Sale. Harper College. 9:30am-3pm. Computer Central Shows 847-940-7547
IL - GRAYSLAKE - LAMARSFEST '97. Lake County, IL Fairgrounds. 8am-2pm. Frank Avellone 847-234-4124
MI - LANSING - Super Computer Sales. Holiday Inn South Conv. Center, 6820 S. Cedar St. 10am-4pm. Computers & You 313-283-1754
NC - KINSTON - Down East Hamfest. Lenoir Co. Fairgrounds. 8am-3pm. 919-524-5724
NH - NASHUA - Computer Show. Sheraton Tara Hotel. 10am-3:30pm. Northern Computer Shows 508-744-8440
NJ - TRENTON - ARRL Hamfest. Delaware Valley Radio Assn. Darryl Foyuth 609-882-2240
NY - YONKERS - WECAFEST '97. Yonkers Raceway, Central & Yonkers Aves. 9am-2pm. Thomas Raffaelli 914-741-6606
OH - MADISON - ARRL Hamfest. Lake County ARA. Roxanne 216-256-0320
PA - WILKES BARRE - Computer Show. Genetti's Best Western. MarketPro 301-984-0880 xt15

MARCH 28-29

GA - COLUMBUS - ARRL Hamfest. Columbus ARC. Randy Hancock 706-596-8820

MARCH 28-29-30

GA - AUGUSTA - Garden City Channel Masters CB Club 15th Annual Break. Radisson Hotel & Conference Center. Moses 706-793-7828

MARCH 29

CA - SACRAMENTO - Computer Show & Sale. Cal Expo. MarketPro 415-456-6730
CA - SAN FRANCISCO - Robert Austin Computer Show. Cow Palace. 1-800-346-0100
CO - DENVER - Metro Computer Show & Swap Meet. 2950 W. 72nd Ave., Westminster. Reputable Systems 303-444-2664
IN - MICHIGAN CITY - Hamfest & Computer Fleamarket. Michigan City High School, 8466 W. Pahs Rd. 8am-2pm. Ron Stahoviak 219-325-9089
MD - GAITHERSBURG - Computer Show. Montgomery Co. Fgnds. MarketPro 301-984-0880 xt15
MI - LIVONIA - Super Computer Sales. Livonia Elks Lodge Hall, 31117 Plymouth Rd. 10am-3pm. Computers & You 313-283-1754
OH - COLUMBUS - Computer Show. Veterans

Events CALENDAR

Memorial. MarketPro 301-984-0880 xt15
PA - HARRISBURG - Computer Show. Farm Show Complex (East Bldg). MarketPro 301-984-0880 xt15
TX - WEATHERFORD - Hamfest. ARC of Parker County. Allen Griffith 817-441-9114
VA - HAMPTON - Computer Show. Hampton Coliseum. MarketPro 301-984-0880

MARCH 30

CA - SANTA ANA - Swapmeet. ACP parking lot. Mary Russo 714-558-8813

APRIL 1997

APRIL 4-5

AL - ALBERTVILLE - Hamfest. Albertville Recreation Center. Fri: 5pm-9pm, Sat: 8am-3pm. Buddy Smith 205-593-2516

APRIL 5

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052
CO - LONGMONT - Hamfest. Longmont ARC. Jim Deeming 303-651-7764
CT - WATERFORD - Ham Radio Auction. Waterford Senior Center. Rte. 85. Tony 860-859-0162
FL - MIAMI - Tailgate Swap Meet. Parking lot Univ. of Miami, main campus. 8am-noon. Walt 305-895-0398
IN - COLUMBUS - Hamfest. Bartholomew Co. 4-H Fairgrounds, Community Bldg. 8am-2pm. Marion Winterberg 812-342-4670
IN - INDIANAPOLIS - AGI Computer Fair. Indianapolis Events Center, 3655 E. Raymond St. 10am-4pm. 317-299-8827
MA - HYANNIS - Computer Show. Tara Hyannis Hotel, West-End Circle. 10am-3:30pm. Northern Computer Shows 508-744-8440
MA - WEST SPRINGFIELD - Computer Show. Eastern States Exposition. 9:30am-4pm. MarketPro 201-825-2229
NH - TWIN MOUNTAIN - North Country ARC & LARK Fleamarket. Town Hall. 8am-3pm. Richard Force 603-788-4428
NJ - TRENTON - Computer Show. Trenton State College. MarketPro 301-984-0880
NY - SYRACUSE - Computer Show. On Center. 9:30am-4pm. MarketPro 201-825-2229
OK - LAWTON - ARRL Hamfest. Lawton Ft. Sill ARC. Bob Morford 405-353-8074
VA - MANASSAS - Computer Show. Manassas Fairgrounds. MarketPro 301-984-0880

APRIL 5-6

CA - VALLEJO - Computer Show & Sale. Solano Co. Fgrds. MarketPro 415-456-6730
FL - CLEARWATER - Computer Show. Harborview Center. MarketPro 301-984-0880
IN - FORT WAYNE - Computer Show. Memorial Coliseum (1/3 of Expo III). MarketPro 301-984-0880
MD - TIMONIUM - ARRL State Convention/Amateur, Computer and Electronic Flea Market, Show & Sale. Timonium Fairgrounds. Sat: 8am-5pm, Sun: 8am-4pm. 410-HAM-FEST
MD - PIKESVILLE - Computer Show. Pikesville Armory. MarketPro 301-984-0880
PA - GREENSBURG - Computer Show. Greengate Expo Center. MarketPro 301-984-0880

APRIL 6

CA - LIVERMORE - Swapmeet. Las Positas College. Noel Anklam 510-447-3857
DE - DOVER - Computer Show. DE State Univ. MarketPro 301-984-0880
IN - FORT WAYNE - Computer Fair. Ramada Hotel, off I-69 Exit 105A. 10am-3pm. AGI 317-299-8827
MA - FRAMINGHAM - Ham Radio/Electronics Flea Market. Framingham High School off Rte. 126. 9am-1pm. Martin Bayes 508-435-0564
MA - TAUNTON - Computer Show. Taunton Holiday Inn. 10am-3:30pm. Northern Computer Shows 508-744-8440
MD - UPPER MARLBORO - Computer Show. The Show Place Arena. MarketPro 301-984-0880
NY - POUGHKEEPSIE - Computer Show. Mid-Hudson Civic Center. 9:30am-4pm. MarketPro 201-825-2229
NY - UTICA - Computer Show. Utica Memorial Aud. 9:30am-4pm. MarketPro 201-825-2229
RI - WEST WARWICK - Computer Show. Civic Center. 9:30am-4pm. MarketPro 201-825-2229

APRIL 11-12

MS - TUPELO - Hamfest & Computer Expo. MS Bldg., Tupelo Furniture Market Complex, Coley Rd. Fri: 6-9pm, Sat: 8am-5pm. Jack Ellis 601-842-7255

APRIL 12

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves
CA - SAN FRANCISCO - Robert Austin Computer Show. Cow Palace. 1-800-346-0100
KY - BOWLING GREEN - ARRL Hamfest. Leon Garrett 502-842-5307
MD - NEW CARROLLTON - Computer Show. Ramada Conference & Exhibition Center. MarketPro 301-984-0880
ME - PORTLAND - Electronics Flea Market/Hamfest. Univ. of Southern ME, Sullivan Gym, Falmouth St. 8am-1pm. Marty Feeney 207-839-5072
MN - ROCHESTER - ARRL Hamfest. Rochester ARC. John Scott 507-732-5091
NY - BUFFALO - Computer Show. Hamburg Fairgrounds. 9:30am-4pm. MarketPro 201-825-2229
PA - FREDERICKSBURG - ARRL Hamfest. Mark Schropp 717-754-7700
UT - OGDEN - State Convention. Kathy Rudnicki 801-547-9218

APRIL 12-13

CA - VENTURA - Computer Show & Sale. Ventura Fairgrounds. MarketPro 415-456-6730
FL - FORT LAUDERDALE - Computer Show. War Memorial Auditorium. MarketPro 301-984-0880
GA - ATLANTA - Ham & Computer Festival. Tim Vogle 770-593-3962
GA - KENNESAW - Computer Show. I-75 Exit 116, go W. on Barrett Pkwy. to Hwy. 41, turn right, go to 2nd traffic light; we're on the right next to "Cowboys." GA Mountain Productions 706-838-4827
GA - NORCROSS - Computer Show. North Atlanta Trade Center. MarketPro 301-984-0880
KY - LOUISVILLE - Computer Show. Commonwealth Conv. Center, Hall B. MarketPro 301-984-0880
NC - WINSTON-SALEM - Computer Show. Lawrence Joel Veterans Memorial. 9:30am-4pm. MarketPro 201-825-2229
NJ - SECAUCUS - Computer Show. Meadowlands Expo. Center. 9:30am-4pm. MarketPro 201-825-2229
OH - CINCINNATI - Computer Show. Cincinnati Gardens. MarketPro 301-984-0880
PA - KING OF PRUSSIA - Computer Show. Valley Forge Conv. Center. MarketPro 301-984-0880
TN - NASHVILLE - Computer Fair. State Fairgrounds. Sat: 10am-5pm, Sun: 10am-3pm. Trade Show Productions 937-263-3378

APRIL 13

CA - SAN DIEGO - Computer Show & Sale. Scottish Rite Center. 10am-5pm. MarketPro 415-456-6730
CA - SANTA ROSA - Computer Show & Sale. Sonoma Co. Fairgrounds. 10am-5pm. MarketPro 415-456-6730
CT - SOUTHINGTON - Electronic Flea Market. Southington High School. 9am-1pm Chet 860-628-9346
IL - CHICAGO - Ham Auction. DeVry Inst. of Tech., 3300 N. Campbell Ave. 773-545-3622
NC - RALEIGH - NCARS 25th Hamfest & Computer Fair. Jim Graham Bldg., NCS Fairgrounds. 8am-4pm. Ronnie Reams 919-217-0263
NH - MANCHESTER - Computer Show. Center of NH Complex. 10am-3:30pm. Northern Computer Shows 508-744-8440
NY - ROCHESTER - Computer Show. The Dome Center. 9:30am-4pm. MarketPro 201-825-2229
OH - CIRCLEVILLE - Hamfest/Computer Show. Pickaway Co. Fairgrounds Coliseum. Roy Ulko 614-477-8310
PA - BLOOMSBURG - ARRL Hamfest. Dave Schack 717-752-6851
VA - ANNANDALE - Computer Show. Northern Virginia Community College. MarketPro 301-984-0880
WI - MADISON - Swapfest. Dan Co. Expo Center Exhibition Hall. MARA 608-245-8890

APRIL 18-19-20

IL - QUAD CITY- Computer Show. QCCA Expo Center. Blue Star Productions 612-788-1901

APRIL 19

CANADA - ONTARIO - PICKERING - Hamfest. Ian Smith 905-427-4873
CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052
MO - JOPLIN - ARRL Hamfest. Joplin ARC. Andy Gabbert 417-673-8371
NH - NASHUA - Electronic Fleamart. Res. Ctr. Church. 617-923-2665
NH - SEABROOK - Computer Show. Seabrook Greyhound Park. 10am-3:30pm. Northern Computer Shows 508-744-8440
PA - LEBANON - Computer Show. Lebanon Valley Expo Center. MarketPro 301-984-0880
VA - HAMPTON - Computer Show. Hampton Coliseum. MarketPro 301-984-0880

APRIL 19-20

FL - TAMPA - Computer Show. State Fairgrounds. MarketPro 301-984-0880
KY - LOUISVILLE - Computer Fair. KY Fair & Expo Center. Sat: 10am-5pm, Sun: 10am-3pm. Trade Show Productions 937-263-3378
MD - GAITHERSBURG - Computer Show. Montgomery Co. Fairgrounds. MarketPro 301-984-0880
NY - STONY BROOK - Computer Show. SUNY Stony Brook. 9:30am-4pm. MarketPro 201-825-2229
PA - MONROEVILLE - Computer Show. Pittsburgh Expo Mart, West Wing. MarketPro 301-984-0880

APRIL 20

CA - LANCASTER - Computer Show & Sale. Antelope Valley Fairgrounds. 10am-5pm. MarketPro 415-456-6730
CA - STOCKTON - Computer Show & Sale. Civic Auditorium. 10am-5pm. MarketPro 415-456-6730
CT - HARTFORD - Robotics Contest. Trinity College. Jake Mendelssohn 860-233-2379
DE - NEW CASTLE - State Convention & Hamfest. Nur Temple, Rte. 13. 9am-3pm. Hal Frantz 302-798-7270
MA - CAMBRIDGE - Hamfest. MIT RS & Harvard Wireless Club. Nick Alternburnd 617-253-3776
ME - PORTLAND - Computer Show. Verillo's Conv. Center, Howard Johnson's Motor Lodge. 10am-3:30pm. Northern Computer Shows 508-744-8440
OH - CANFIELD - Hamfest. Canfield Fairgrounds, State Rte. 46. 8am-3pm. Don Stoddard 330-793-7072
PA - WILKES BARRE - Computer Show. Genetti's Best Western. MarketPro 301-984-0880
VA - RICHMOND - Computer Show. The Showplace, Showplace Bldg. MarketPro 301-984-0880

APRIL 25-26

AR - LITTLE ROCK - Hamfest. Little Rock Expo Center, Exit 126, I-30. Fri: 4pm-9pm, Sat: 8am-5pm. Jim Blackmon 501-246-7833
NE - SOUTH SIOUX CITY - Iowa State Convention. Mike Nickolaus 402-494-6070

APRIL 25-26-27

MN - ST. PAUL - Computer Show. State Fair Grounds. Blue Star Productions 612-788-1901

APRIL 26

CA - BAKERSFIELD - Computer Show & Sale. Kern Co. Fairgrounds. MarketPro 415-456-6730
CA - GLEN ELLEN - ARRL Hamfest. McDougal Hall, Sonoma Developmental Center, 15000 Arnold Dr. 8am-1pm. Darrel 707-996-4494
CO - DENVER - Metro Computer Show & Swap Meet. 2950 W. 72nd Ave., Westminster. Reputable Systems 303-444-2664
FL - ORLANDO - Computer Show. Orlando Centroplex. MarketPro 301-984-0880
NJ - HARMONY - Cherryville Hamfest. Warren Co. Farmers Fairground. 8am-2pm. Charlie Kosman 908-788-4080
NY - WHITE PLAINS - Computer Show. Westchester Co. Center. 9:30am-4pm. MarketPro 201-825-2229
OH - DAYTON - Computer Show. Montgomery Co. Fairgrounds. MarketPro 301-984-0880
OR - ROSEBURG - Hamfest & Computer Show. DC Fairgrounds. 9am-3pm. Ed Pahl 541-673-1310
VA - CHANTILLY - Computer Show. Capital Expo Center. MarketPro 301-984-0880

APRIL 26-27

CA - SACRAMENTO - Computer Show & Sale. Cal Expo. MarketPro 415-456-6730
DE - NEWARK - Computer Show. Univ. of DE. MarketPro 301-984-0880
FL - SARASOTA - Computer Show. Municipal Auditorium. Frank Cox 941-954-0202
NC - CHARLOTTE - Computer Show. Charlotte Merchandise Mart. 9:30am-4pm. MarketPro 201-825-2229
NY - WHITE PLAINS - Computer Show. Westchester Co. Center. 9:30am-4pm. MarketPro 201-825-2229

APRIL 27

CA - OXNARD - Computer Show & Sale. Community Center. 10am-5pm. MarketPro 415-456-6730
FL - MELBOURNE - Computer Show. Melbourne Auditorium. MarketPro 301-984-0880
IL - ARTHUR - MARK Hamfest. Moultrie/Douglas Co. Fairgrounds. 8am-1pm. Ralph Zancha 217-873-5287
IL - GLEN ELLYN - Computer Show & Sale. College of DuPage. Main Arena of Phys Ed Bldg. Corner of Park Blvd. & College Rd. 9:30am-3pm. Computer Central Shows 847-940-7547
MA - WESTPORT - Computer Show. Whites of Westport. 10am-3:30pm. Northern Computer Shows 508-744-8440
MN - SHAKOPEE - Hobby Electronics Show. Canterbury Park. 8am-1pm. Tim 612-474-9232
NJ - PARSIPPANY - Computer Show. Parsippany Hilton. 9:30am-4pm. MarketPro 201-825-2229
NY - FISHKILL - Mt. Beacon Hamfest. John Jay High School. 8am-1pm. Ken Akasofu 914-485-9617
OH - ATHENS - ARRL Hamfest. Athens Co. ARA. John Cornwell 614-593-6474
OH - COLUMBUS - Computer Show. Ohio Expo Center. MarketPro 301-984-0880
VA - FREDERICKSBURG - Computer Show. Fredericksburg Armory. MarketPro 301-984-0880
VA - HARRISONBURG - Computer Show. Rockingham Center. MarketPro 301-984-0880

MAY 1997

MAY 2-3-4

WI - WAUSAU - Computer Show. Wausau/Marathon Co. Park. Blue Star Productions 612-788-1901

MAY 3

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052
IN - INDIANAPOLIS - AGI Computer Fair. Indianapolis Events Center. 3655 E. Raymond St. 10am-4pm. 317-299-8827
IN - SOUTH BEND - Computer Show. Century Center. MarketPro 301-984-0880
MA - WEST SPRINGFIELD - Computer Show. Eastern States Exposition. 9:30am-4pm. MarketPro 201-825-2229
MD - NEW CARROLLTON - Computer Show. Ramada Conference & Exhibition Center. MarketPro 301-984-0880
MI - CADILLAC - Hamfest. Cadillac Middle School. 8am-2pm. Dan KE8KU 616-775-0998

MAY 3-4

CA - VALLEJO - Computer Show & Sale. Solano Co. Fgrds. MarketPro 415-456-6730
FL - FORT LAUDERDALE - Computer Show. War Memorial Auditorium. MarketPro 301-984-0880
PA - HARRISBURG - Computer Show. Farm Show Complex, East Bldg. MarketPro 301-984-0880
TX - ABILENE - ARRL West TX Conv. & Hamfest. Abilene Civic Center. Sat: 8am-5pm, Sun: 9am-2pm. Peg Richard 915-672-8889

MAY 4

CA - LIVERMORE - Swapmeet. Las Positas College. Noel Anklam 510-447-3857
CA - SAN DIEGO - Computer Show & Sale. Scottish Rite Center. 10am-5pm. MarketPro 415-456-6730
IL - SANDWICH - Hamfest. Sandwich Fairgrounds. 8am-1pm. Bob Yurs 815-895-3219
IN - BLOOMINGTON - Hamfest. Monroe Co. Fairgrounds. 8am-3pm. John Anderson 812-332-3734 after 5pm
IN - FORT WAYNE - Computer Show. Memorial Coliseum, 1/2 of Exhibit Hall. MarketPro 301-984-0880
IN - NOBLESVILLE - AGI Computer Fair. Hamilton Co. 4-H Grounds (off Pleasant St. on SR-37).10am-3pm. 317-299-8827
MD - FREDERICK - Computer Show. Frederick Fairgrounds, MarketPro 301-984-0880
MD - HAGERSTOWN - Hamfest & Computer Show. Hagerstown Junior College, Athletic, Recreation, & Community Center. ARA 301-791-3010
NH - PORTSMOUTH - Computer Show. Yoken's Conference Center. 10am-3:30pm. Northern Computer Shows 508-744-8440
NY - POUGHKEEPSIE - Computer Show. Mid-Hudson Civic Center. 9:30am-4pm. MarketPro 201-825-2229
NY - YONKERS - Electronic Flea Market. Lincoln High School. Otto 914-969-1053
VA - ROANOKE - Computer Show. Roanoke Civic Center. MarketPro 301-984-0880

MAY 9-10-11

IA - DES MOINES - Computer Show. State Fairgrounds. Blue Star Productions 612-788-1901

MAY 10

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves
MA - STURBRIDGE - Computer Show. Sturbridge Host Hotel. 10am-3:30pm. Northern Computer Shows 508-744-8440
SD - HURON - Amateur Electronics Swapfest. National Guard Armory, State Fairgrounds. 8am-3pm. Lloyd Timperley 605-352-7896 eves
WI - MANITOWOC - Hamfest & Computer Swapfest. County Expo Ctr., intersection of Hwys 42-151 & I-43 on Co. R. Red 414-684-9097 days, Glenn 414-684-7096 day or evening

MAY 10-11

FL - WEST PALM BEACH - Computer Show. South Florida Fairgrounds. MarketPro 301-984-0880
GA - KENNESAW - Computer Show. I-75 Exit 116, go W. on Barrett Pkwy. to Hwy. 41, turn right, go to 2nd traffic light; we're on the right next to "Cowboys." GA Mountain Productions 706-838-4827
MD - PIKESVILLE - Computer Show. Pikesville Armory. MarketPro 301-984-0880
NY - STONY BROOK - Computer Show. SUNY Stony Brook. 9:30am-4pm. MarketPro 201-825-2229
TN - NASHVILLE - Computer Show. State Fairgrounds, Exhibition Bldg. MarketPro 301-984-0880
VA - CHANTILLY - Computer Show. Capital Expo Center. MarketPro 301-984-0880
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TEKTRONIX 7000 SERIES: 7CT1N curve tracer $350. **7D20** digital storage $700. **7L5/L3** spectrum analyzer, 20Hz-5MHz, 10Hz RBW $1,400; with tracking generator $1,900. **7S12, S-6, S-52** time domain reflectometer $1,400. **7S14** 1GHz sampler $600. Excellent condition! All with warranty. Pepper Systems, 214-353-0257.

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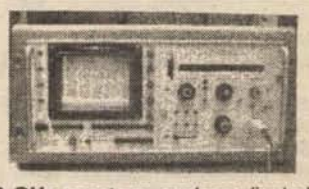

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HP 7475 plotter with HB-IB interface $200. JDR 2000 oscilloscope $150. Tek 184-Time Mark generator $40. Tek 561A oscilloscope $50. Tek Z plug $20. HP 1610A, 1610B logic state analyzer $50. Tek P6452, P6455 data acquisition $25. Fluke 2204A scanner $50. Data precision 1350 $25. Saint Clair multimeter $40. Simpson Multimeter 461 $40. Data precision 610 $50. Call 714-827-7345.

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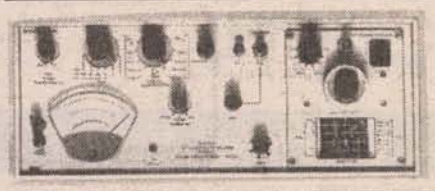

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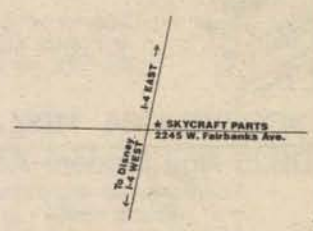

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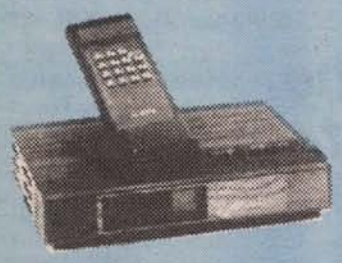

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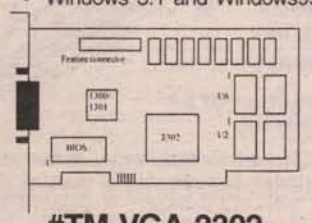

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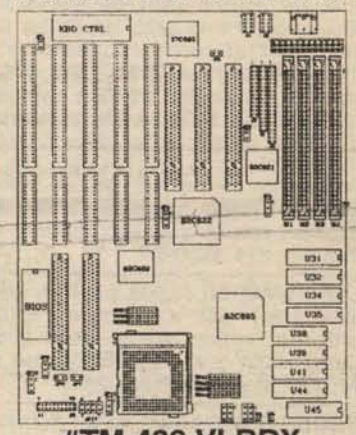

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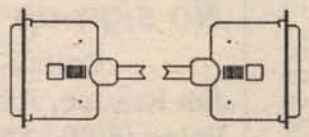

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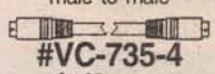

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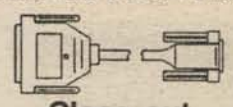

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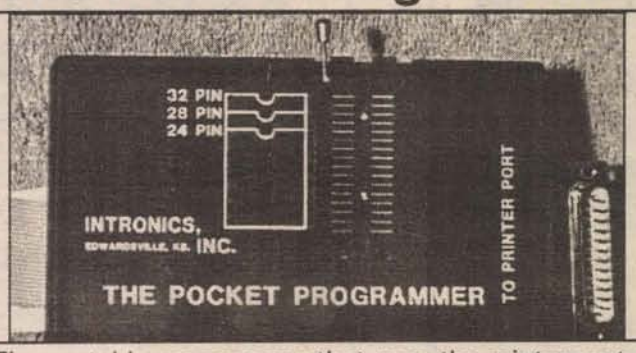

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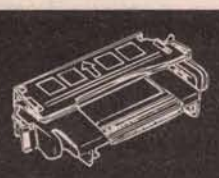

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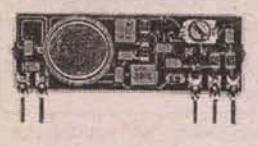

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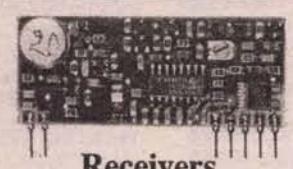

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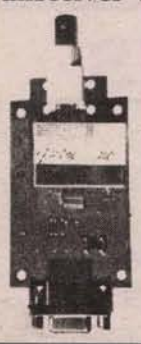

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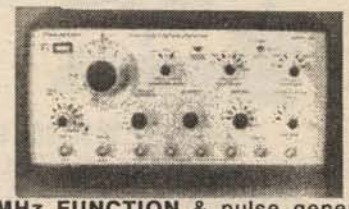

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Dealing With Resistive Sensors

Open Channel

by Joseph J. Carr
K4IPV

Sensors are electronic or electrical devices that change in some significant way in response to an applied stimulus. One common class of sensor is the resistive sensor. We find in this class a variety of position sensors, angle sensors, pressure sensors, temperature sensors, and light sensors, all based on slightly different physical phenomena.

Potentiometer Sensors

Resistors come in a variety of forms, one of which is the potentiometer. The "pot" (Figure 1) is a variable resistor with three terminals and an actuator shaft that can change the position of a tap on the resistor body. The total resistance (R) is measured between the two outside terminals, while the fraction of R from one outside terminal to the center terminal is R_A and from the other to the center terminal is R_B. The center terminal is connected to a tap that rides on the resistive element. In terms of Figure 1, the overall resistance is R. The resistance from the left terminal to the center terminal is R_A, which is equal to $R - R_B$. Similarly, $R_B = R - R_A$.

The term "potentiometer" comes from the late 19th century when it was used as a precision means of providing reference voltages. A highly accurate voltage source, such as a Weston cell, was connected across the outside terminals. By knowing the position of the tap, we also know the value of the voltage appearing between one end of the pot and the wiper.

Several different forms of element are available for use in potentiometers: wire, carbon composition, and metal film. The wire form uses a resistive wire wrapped uniformly around a support. The carbon composition type uses a flat surface on which the appropriate carbon composition material is deposited. The metal film type is conceptually similar to the carbon form, but a metallic film is deposited on a ceramic substrate.

The taper of the potentiometer refers to the profile of resistance change with change of tap position. Most commonly used for sensor applications is the linear taper potentiometer. These devices have the same change of resistance (ΔR) for any unit change of tap position (ΔX). The audio taper is shaped to optimize the use of the potentiometer as a audio volume control. The idea is to get a smooth transition of volume (the human ear is markedly non-linear). Still another form is the logarithmic taper, i.e., the change of resistance changes as the logarithm of the position change.

Figure 2 shows one form of potentiometer often seen in sensor applications: the slide or linear potentiometer. The body of the potentiometer is a rectangular shape, and has a slot cut into one side for nearly the entire length. The slot accommodates the actuator for the wiper. If we couple the wiper actuator to some external mechanical device that changes in position "X" (represented here by a pointer and a scale), then the position of the wiper actuator gives an indication of the position of the external device. In some cases, mechanical linkage is used to reduce the mechanical translation distance to the "throw" of the actuator wiper.

Figure 3 shows the equivalent in a rotary shaft potentiometer. These devices are the most familiar form of pot for most readers, I suspect. The resistive element is arranged in a circular pattern coaxial to the actuator shaft. The respective values of R, R_A, and R_B provide the angular position of the shaft.

Several different forms of angular potentiometer are available. Most common forms have a resistive element that covers 270 degrees of the circuit (although I've seen 310-degree pots, as well). Some of them don't have stops at either end of the range, but have 360-degree rotation. Some of these pots have a fourth terminal at the crossover point to indicate zero position. Another variety is the multi-turn potentiometer. These devices cover the entire resistance range in 5, 10, 15, or 20 turns of the shaft.

A number of years ago, I worked repairing medical electronic devices. One of those devices was a syringe pump used in a research laboratory. The pump had a worm gear mechanism and a holder for a 50 cc syringe (one of those big honkin' jobs you hate to see the doctor coming at you with!). A precision step motor turned the worm gear, moving a push plate against the back of the syringe (shown simplified in Figure 4). A linear potentiometer

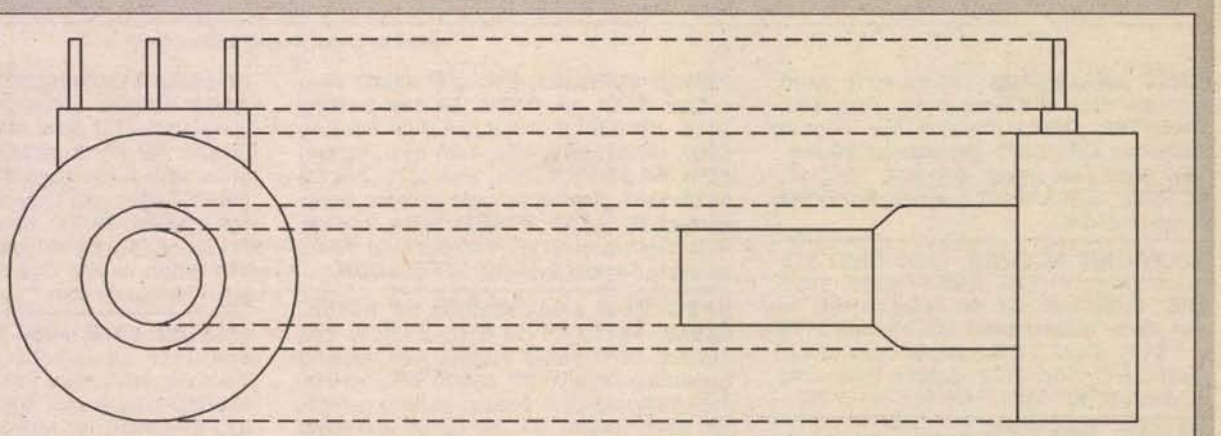

Figure 3
Normal rotary potentiometer.

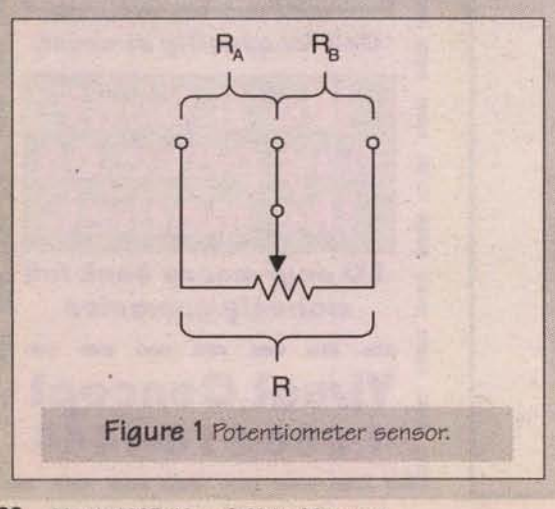

Figure 1 Potentiometer sensor.

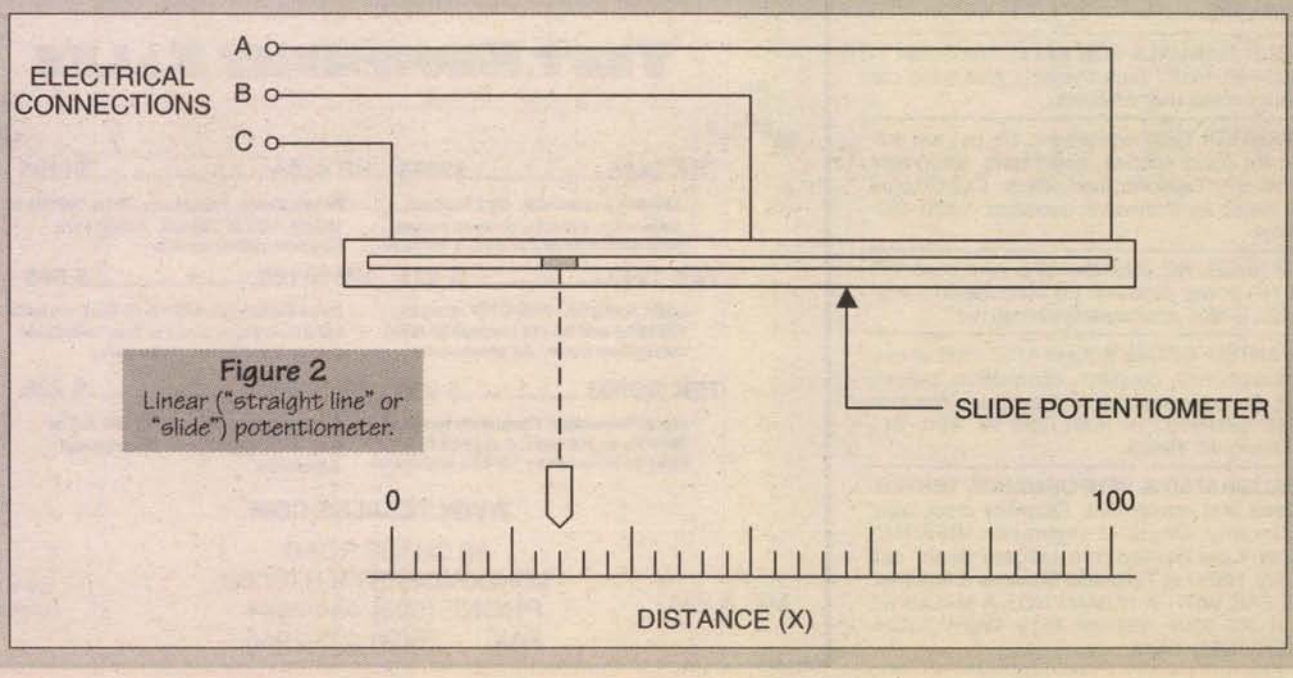

Figure 2
Linear ("straight line" or "slide") potentiometer.

was ganged to the worm gear (or in version to the push plate).

The syringe pump potentiometer is a displacement sensor, i.e., its resistance provides information on the position of the wiper, hence, in turn, the position of the plunger of the sensor. By simple ratio and proportion (assuming a linear taper potentiometer is used), we can figure out the volume of material inside the syringe has been delivered (R_A), i.e., flow volume, and how much is left (R_B) in the syringe. Indirectly, we can also measure flow rate because flow rate is flow per unit of time. We can take a smoothed measure of flow rate by performing a little calculus on flow volume.

As an aside, we can often indirectly measure various parameters by taking either the derivative or integral of some related parameter. For example, a potentiometer displacement sensor provides an indication of position X. If we take the first derivative of X (i.e., dX/dT) we get the velocity, and if we take the second derivative of X (or first derivative of velocity) we get acceleration. Similarly, integrating flow rate gives us flow volume. This is one of the uses of integrator and differentiator circuits.

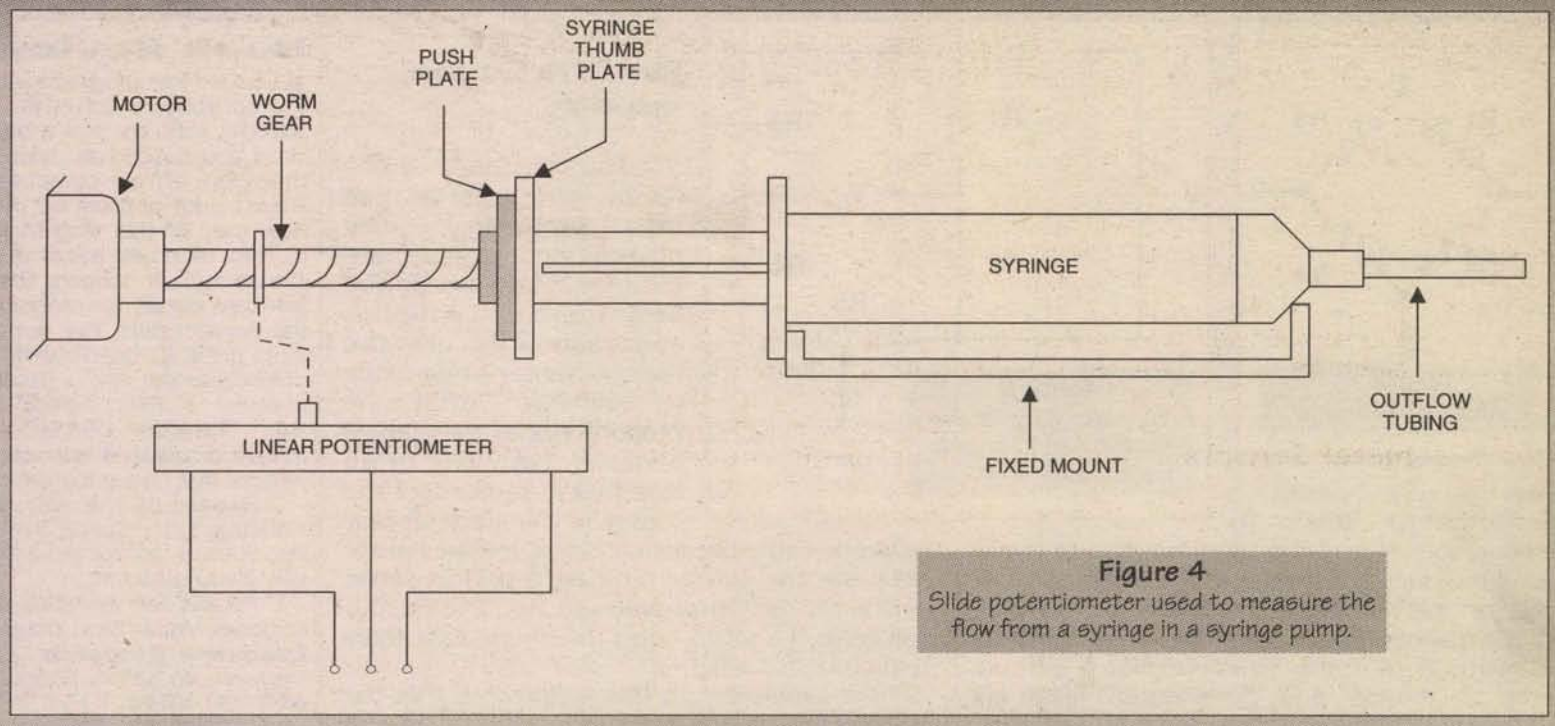

Figure 4
Slide potentiometer used to measure the flow from a syringe in a syringe pump.

Piezoresistive Strain Gauges

The resistance of any specific conductor is directly proportional to its length and inversely proportional to its cross-sectional area (see Figure 6A). Resistance is also directly proportional to a property of the conductor material called resistivity. Equation 1 shows clearly that resistance is proportional to resistivity and the length of the conductor, and inversely proportional to the cross-sectional area of the conductor.

$$R = \frac{\rho L}{A} \qquad (1)$$

Where:
ρ is the resistivity in ohm-centimeters (Ω-cm)
L is the length in centimeters (cm)
A is the cross-sectional area in square centimeters (cm^2),or πR^2

The word piezoresistivity denotes the resistance change that takes place when either the length, area, or both of a conductor are changed. Figure 6A shows a cylindrical conductor with an initial length (L_o) and a cross-sectional area (A_o).

When a compression force (F1) is applied, as in Figure 2B, the length reduces and the cross-sectional area increases. This situation results in a decrease in the electrical resistance. Mathematically:

$$R = (R_o - \Delta R) \propto \left(\frac{L_o - \Delta L}{A_o + \Delta A}\right) \qquad (2)$$

Similarly, when a tension force is applied (Figure 2C), the length increases and the cross-sectional area decreases, so the electrical resistance will increase.

$$R = (R_o + \Delta R) \propto \left(\frac{L_o + \Delta L}{A_o - \Delta A}\right) \qquad (3)$$

In either tension or compression cases — provided that the physical change is small — the change of electrical resistance is a nearly linear function of the applied force, so can be used to make measurements of that force. Sensors that use piezoresistivity to measure forces are called strain gauges.

Strain Gauges

A strain gauge is a piezoresistive — element — either wire, metal foil, or semiconductor, designed to create an electrical resistance change when a force is applied. Strain gauges can be classified as either bonded or unbonded types. Figure 6 shows both methods of construction.

The unbonded strain gauge is shown in Figure 6A, and consists of a wire resistance element stretched taut between two flexible supports. These supports are configured in such a way as to place a tension or compression force on the taut wire when external forces (F) are applied.

In the particular example shown, the supports are mounted on a thin metal diaphragm that flexes when a force is applied. A tension force will cause the flexible supports to spread apart, placing increased tension force on the wire and thereby increasing its resistance.

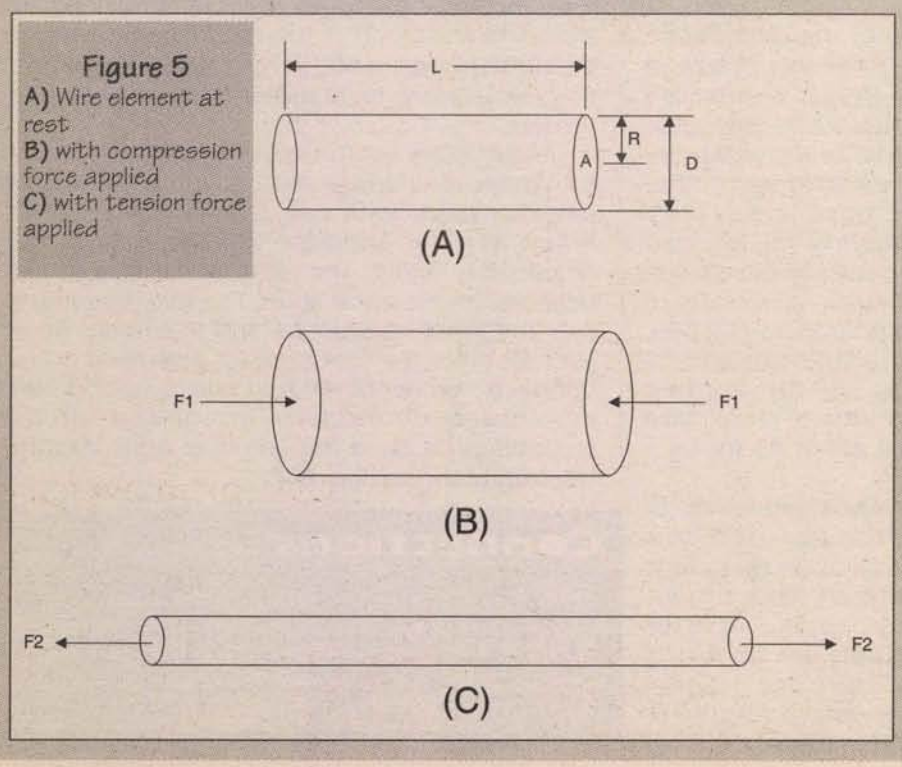

Figure 5
A) Wire element at rest
B) with compression force applied
C) with tension force applied

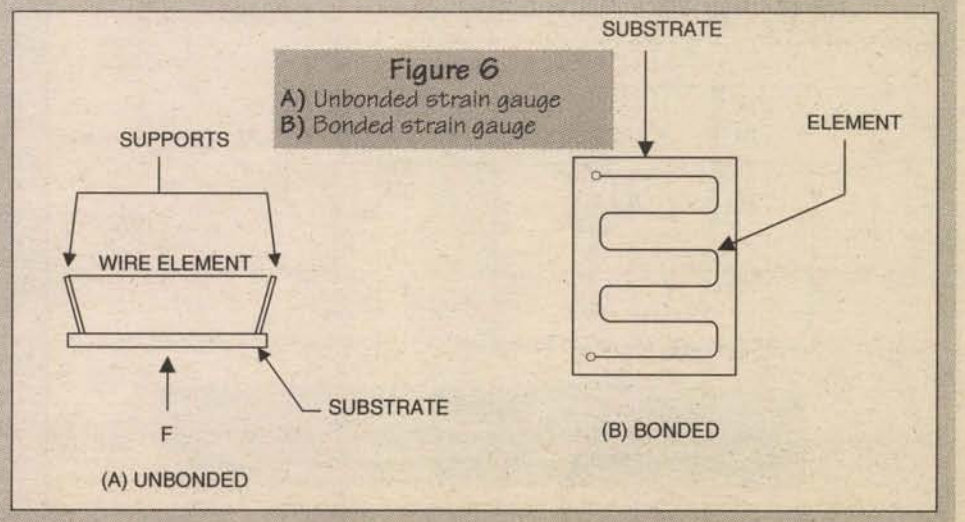

Figure 6
A) Unbonded strain gauge
B) Bonded strain gauge

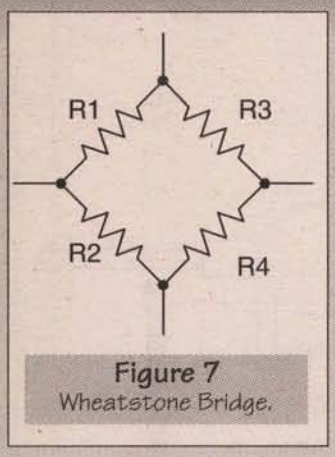

Figure 7
Wheatstone Bridge.

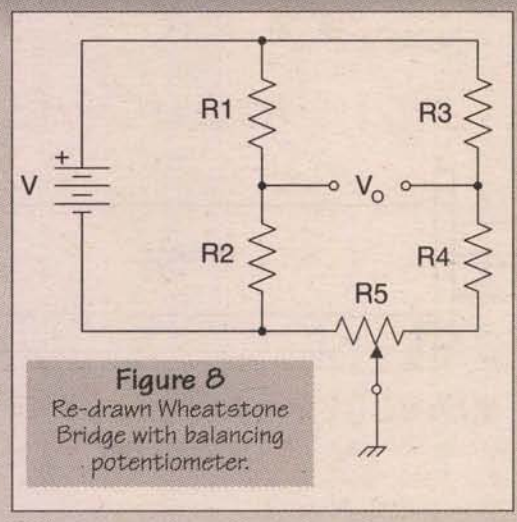

Figure 8
Re-drawn Wheatstone Bridge with balancing potentiometer.

Alternatively, when a compressing force is applied, the ends of the supports tend to move closer together, effectively placing a compression force on the wire element and thereby reducing its resistance. In actuality, the wire's resting condition is tautness, which implies a tension force, so "tension" and "compression" mean an increase or decrease in normal tension, respectively.

The bonded form of strain gauge is shown in Figure 6B. In this type of device, a wire, foil, or semiconductor element is cemented to a thin metal diaphragm. When the diaphragm is flexed, the element deforms to produce a resistance change.

The linearity of both types of strain gauge can be quite good, provided that the elastic limits of the diaphragm and element are not exceeded. It is also necessary to ensure that the change of length is only a small percentage of the resting length.

In the past, the "standard wisdom" held that bonded strain gauges are more rugged, but less linear than unbonded models. Although this may have been the situation at one time, recent experience has shown that modern manufacturing techniques can produce rugged, linear, reliable units of both types of construction.

Strain Gauge Sensitivity

The sensitivity of the strain gauge is expressed in terms of unit change of electrical resistance per unit change of length, and is most often given in the form of the gauge factor (S) for the element:

$$S = \left(\frac{\Delta R / R}{\Delta L / L}\right) \qquad (4)$$

Resistive Sensor Circuitry

The resistance of the resistive sensor can be used for making the measurement in question, but that is not usually the best approach. A better approach is to use the resistive sensor to generate a voltage that is proportional to the applied stimulus. One way to do that trick is to connect the sensor in a voltage divider network. These circuits consist of a fixed resistor (R1) and the sensor resistance (R2) in series across an excitation voltage (V). The output voltage (V_o) is taken across the sensor, so is equal to (V x R2)/(R1 + R2).

The problem with this approach is that the voltage will always have some non-zero value when the applied stimulus is zero, unless the resistance of the sensor goes to zero (or very near it) at the same time. Lots of luck finding that situation. A better way is to use a Wheatstone Bridge circuit.

Figure 7 shows the classic Wheatstone Bridge. It's been around since the mid-19th century, but still forms the basis of a gozillion electronic instruments. One way to look at this circuit is as a pair of voltage dividers: R1/R2 forms one and R3/R4 forms the other. If a voltage is applied across these voltage dividers (e.g., one side of the battery connected to junction R1-R3, and the other to junction R2-R4), then the output voltage appears across the opposite nodes (e.g., junctions R1-R2 and R3-R4).

Consider the situation where junction R2-R4 is grounded. In this case, the output voltage is the difference between the voltage drop across R2 and the voltage drop across R4: $V_o = V_{R2} - V_{R4}$. The nice thing about this circuit is that the output voltage can be made zero under zero stimulus by selecting resistor values. The output voltage is zero when the ratios of the two voltage dividers are equal to each other: R1/R2 = R3/R4.

A more practical version of the Wheatstone Bridge is shown in Figure 8. In this circuit, a balancing potentiometer (R5) is connected between R2 and R4 at junction R2-R4. The value of R5 is usually a fraction of R2 or R5, which are set equal to each other in most cases. By adjusting R5, we can zero-out any offsets due to minor variations in the resistances of R1-R4. The adjustment process is to set the applied stimulus to zero, and then adjust R5 for V_o = 0.

Different forms of sensor use different variations on the bridge theme. In some circuits, only one resistor (usually R2 or R4) is a sensor. Some temperature sensors or displacement sensors work this way. In other cases, two resistors (e.g., R2 and R4) will be sensors, and the other two fixed.

One example of this is the differential thermometer, i.e., a thermometer that measures the difference between two temperatures. An indoor-outdoor thermistor pair is used in this way on an environmental temperature controller for home heating systems. Many sensors are available in which all four resistors are sensor elements. This is the most linear approach. Fluid pressure sensors are usually based on this approach.

One of the problems of the bridge circuit is that output voltages tend to be very small. One fluid pressure sensor used in human blood pressure measurements, for example, offers an output potential of 50 µV per volt of excitation per mmHg of pressure. Another problem is that, in some cases, the resistances of the bridge elements are quite high (as in optical or thermal sensors), so the output impedance of the circuit is also quite high. The "looking back" source resistance of the bridge, when all four arms are the same resistance, is the resistance of any one element (if you doubt this, apply Thevinin's theorem). Clearly an amplifier is in order for most sensors.

Figure 9 shows the standard amplifier circuit for Wheatstone Bridge sensors. It is a differential amplifier made with one operational amplifier. When R4 = R5 and R6 = R7, the gain of the amplifier is R7/R4. The amount of gain to use depends on the application. The rule-of-thumb is that the input resistors R4 and R5 should be at least 10 times the looking back resistance of the bridge. A number of modern bridge sensors take advantage of modern integrated circuit technology to build the amplifier right into the housing of the sensor. **NV**

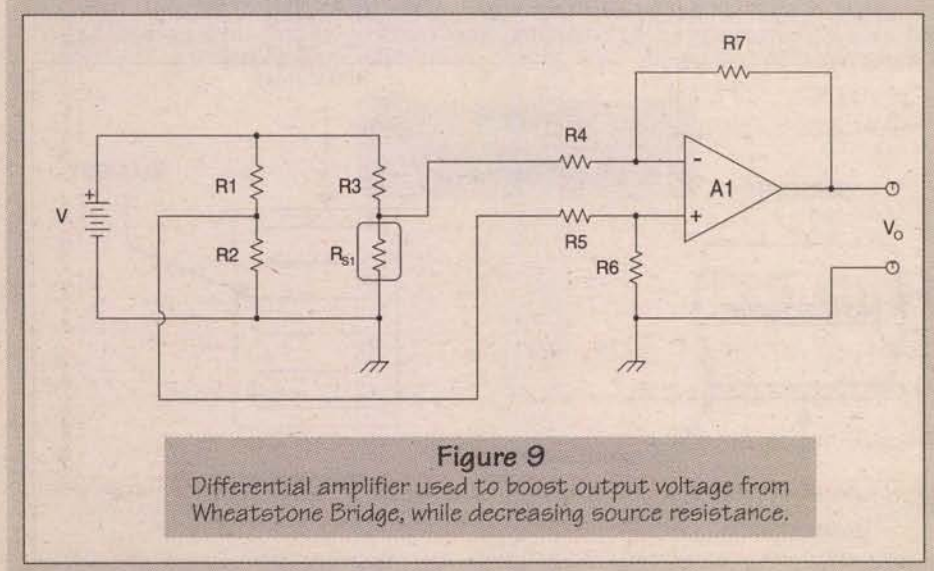

Figure 9
Differential amplifier used to boost output voltage from Wheatstone Bridge, while decreasing source resistance.

Book Review

If you are into programming, building, or interfacing to computers (whether the big ones or BASIC Stamps), then there is a book that you need to see. Have you noticed all those gadgets and accessories that work off the computer's parallel printer port? There's a lot of them on the market. Ever wondered how they do that neat trick, and how you could do it? If so, then take a look at *Parallel Port Complete* by Jan Axelson. It contains the complete hardware and software details for programming and interfacing to the parallel port. I've got a copy to review, and it looks great! It's been awhile since I've seen a book so practical as this one ... *Parallel Port Complete* is a real keeper! I first heard about the book on the Parallax BASIC Stamp list server (majordomo@parallaxinc.com), and obtained a copy when it first hit the market in early January.

[**Note:** By the way, you might not want to subscribe to the Stamp list server unless you are really into Stamps, and/or like E-Mail ... a lot will come your way if you subscribe.]

Parallel Port Complete can be bought for $39.95 (includes Visual Basic diskette), and is available from **Lakeview Research**, 2209 Winnebago Street, Madison, WI 53704. Phone: **608-241-5824**, or FAX **608-241-5848**. E-Mail to jaxelson@lvr.com — The cover image and additional information can be found at their website: http://www.lvr.com/ppcpress/htm

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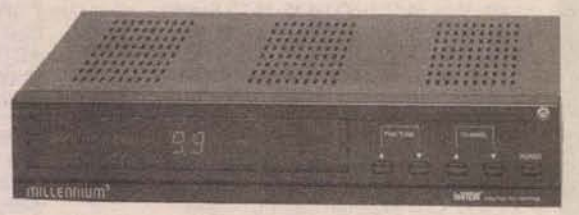

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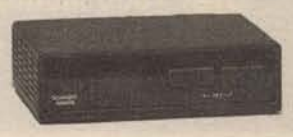

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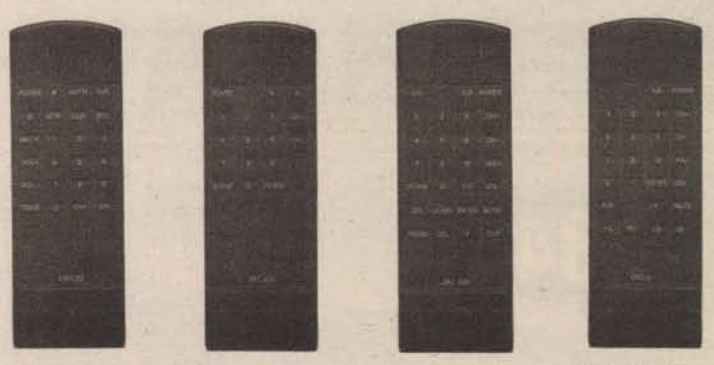

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Stamp Applications:

Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

by Scott Edwards

In the olden days, say 20 years ago, analog-to-digital converters (ADCs) were rare and expensive. Designers who needed to measure voltages generally built their own ADCs using a building block called a comparator. Even now that ADCs are no longer exotic, comparator-based tricks are still popular. Comparator ADCs are much cheaper than comparable packaged ADCs, and they're a good education for those who wonder what's under the hood of ADC chips.

Analog-to-Digital Conversion The Old-Fashioned Way

Using comparators to measure voltage and a total-shutdown power supply

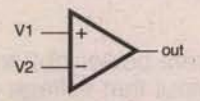
This month, we'll look at comparators and the ADC circuits you can build with them. As an added bonus, we'll design a power supply that turns a system on at the touch of a button and off at the flip of a bit.

The Hotter/Colder Game, on a Chip

As the name suggests, a comparator is a circuit that compares two inputs. It's a close relative of the operational amplifier (op amp) and uses the same schematic symbol. See Figure 1.

A comparator takes two input voltages and compares them. If the voltage at the + input (called the non-inverting input) is higher, then the output is 1; if the - (inverting) input is higher, the output is 0.

The rules of comparator operation don't say what happens when the voltages are equal. In practical circuits, there's almost no such thing as "equal" where comparators are concerned. The comparator's gain is so high and tiny noise voltages so unavoidable that "equal" ends up looking like nervous twitching between the greater-than and less-than conditions.



IF V1 > V2 THEN out = 1
IF V1 < V2 THEN out = 0

Figure 1. Comparator symbol and operation.

Imagine how you might use a comparator to measure an unknown voltage. Let's assume you had a variable voltage source with a calibrated dial. You'd connect that to the inverting input of the comparator, and the unknown voltage to the non-inverting input. You'd also connect an LED to the comparator output so you could see the result of the comparison (1 or 0; on or off).

Starting at one end of the dial, you'd adjust the voltage source until the comparator output changed state. For example, suppose you start at 0 volts. The comparator outputs 1 because the unknown voltage is higher. You dial upward gradually, stopping as soon as the comparator outputs 0. Checking the dial, you find that this happens at about 1.5V. So you know that the unknown voltage is very close to 1.5V.

Figure 2 and Listing 1 show how a BS1 or Counterfeit controller can be used to make that kind of voltage measurement using one section of an LM339 comparator. The Stamp's PWM output serves as the calibrated variable voltage, which the program adjusts up from 0V while watching the comparator output. The result is expressed as a number from 0 to 255, where 0 is 0V and 255 is 5V. Each unit is approximately 19.6 millivolts (5/255).

If you run the program, or just think about the example, you'll recognize a weakness in this strategy. Since the variable voltage starts upward from 0, the further the unknown voltage is from 0, the more trials (and therefore time) it takes to complete a measurement. In the Listing 1 example, measurements of 10 units or less take a fraction of a second, while measurements of 200+ units take a couple of seconds.

There's a common-sense alternative that's easy to understand: Suppose we were playing a guessing game in which I pick a number between 0 and 255, and you have to guess that number. As a hint, I tell you whether each guess is higher or lower than my number.

If you wanted to win the game quickly, you would not start at 0 and guess 1, 2, 3, 4 ... until you reached the correct number. More than likely, you'd start with a number in the middle of the range, say 128, and use the higher/lower clue to guide your next guess. For instance, if you said "128" and I replied "higher," you could eliminate the whole range of 0 through 128 from further guessing!

Now you could split the remaining range of 129 to 255 in half, guessing 192. I say "lower" and your choices narrow to 129 to 191. By continuing to split and narrow the range with each guess, you'd be sure to have the correct number in just eight guesses.

That's pretty much the way Listings 2 and 3 (BS1 and BS2) work. The systematic divide-and-conquer approach is much faster than Listing 1.

Listing 1. Simple (but dumb) Comparator ADC for BS1

```
' Program: COMP_AD1.BAS
' (Single-slope ADC with the BS1 and a comparator)
' This program implements a single-slope ADC with a comparator.
' The unknown voltage goes to the comparator's + input and the
' Stamp's PWM output to the - input. The Stamp incrementally
' increases the PWM output to the comparator reference until
' the reference exceeds the input voltage. This is a simple
' (albeit not very intelligent) way to make an ADC. One major
' drawback of this approach is that the higher the unknown
' voltage, the longer the conversion takes. See the program
' COMP_AD2.BAS for a vastly improved version.

SYMBOL refOut   =  0     ' Comparator reference.
SYMBOL compIn   =  pin1  ' Comparator output.
SYMBOL ADCres   =  b2    ' Analog-to-digital result.

' Demonstration loop: take a conversion, display it, and loop.
again:
  gosub ADconvert        ' Perform conversion.
  debug ADCres           ' Display it.
goto again               ' Do it again.


' ADC conversion routine.
ADconvert:
  ADCres = 0                          ' Start at 0 volts.
convLoop:
  PWM refOut,ADCres,1                 ' Output 1 PWM cycle.
  if compIn = 0 then done             ' If reference > unknown, done.
  ADCres = ADCres + 1                 ' Otherwise, increase by 1.
  if ADCres <> 0 then convLoop        ' If rollover from 255 to 0, quit.
done:
return                                ' Return to program.
```

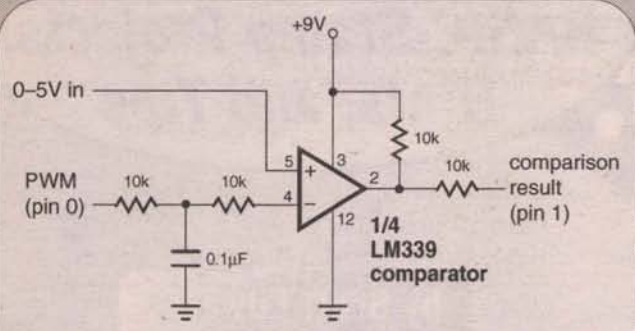


Figure 2. Hook-up for Stamp-comparator ADC.

On a BS1, it runs at 13 conversions per second; a BS2 gets 37.

Speaking of speed, note that the comparator ADC has a weakness in common with most low-end packaged ADCs — it's not good with rapidly changing signals. If the signal changes while the ADC is trying to measure it, the result is not valid. It's like taking a photo of a fast-moving car using a slow shutter — the image is blurred. To make an ADC work correctly with fast-changing signals, you need the electronic equivalent of a fast shutter, a circuit called a sample-and-hold. As the name implies, this circuit grabs a sample of the input signal, then the ADC measures that. No blur.

There are plenty of applications — like temperature sensing — that move slowly enough not to require a sample-and-hold circuit. A rule of thumb is that if you can accurately measure the voltage with a digital meter (good for only a few samples a second), then the comparator ADC will be just fine. If the signal would be more appropriately viewed on an oscilloscope, you definitely need a sample-and-hold.

Building a discrete sample-and-hold circuit would be an excellent educational experience, but wouldn't make much practical sense, since it might add a dozen components to the circuit. If you need a sample-and-hold, go ahead and buy a packaged ADC that includes one. See the fourth installment (issue 4)of this column (available from the *Nuts & Volts* web site) for a description of the LTC1298, a 12-bit ADC with sample-and-hold capability, or see Sources for the LTC1298 AppKit.

Going Further

Now that you have seen how a comparator works, you may think of other applications. For example, if you want an indication when a voltage is above or below a reference level (e.g., low-battery warning), the basic comparator circuit is a ready-made answer. Scouring textbooks and application notes will suggest other uses: zero-crossing detectors for AC, Schmitt Triggers to clean up slow/noisy signals, level detectors, squarewave generators, etc.

One obvious modification of the example would be to use the remaining sections of the LM339 to build a four-channel ADC. You'd connect all of the inverting inputs (-) together, and the outputs to separate Stamp pins. To take a measurement from a particular channel would require looking at only the appropriate output, ignoring the others.

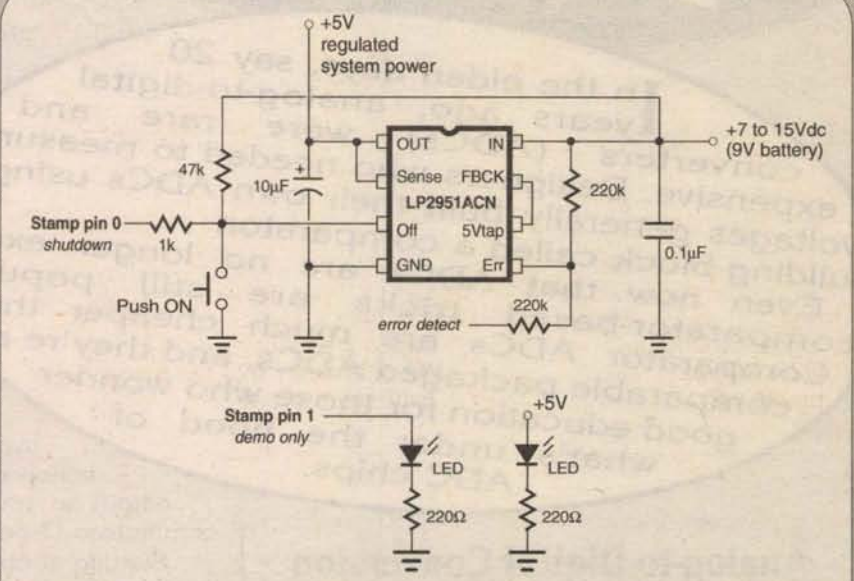


Figure 3. Total-shutdown power supply.

Listing 2. Improved Comparator ADC for BS1

```
' Program: COMP_AD2.BAS
' (Binary-search ADC with the BS1 and a comparator)
' This program implements an ADC using a comparator.
' The unknown voltage goes to the comparator's + input and the
' Stamp's PWM output to the - input. The Stamp systematically
' searches for the unknown voltage by splitting the possible
' range of voltages in half, seeing whether the unknown is
' higher or lower, then splitting that range in half ...
' This approach assures that the conversion is always
' finished in the shortest time possible. The conversion
' subroutine presented here runs at about 13 conversions/second.

SYMBOL refOut     =    0      ' Comparator reference.
SYMBOL comp_p     =    pin1   ' Comparator output (pin).
SYMBOL ADCres     =    b2     ' Analog-to-digital result.
SYMBOL pwrTwo     =    b3     ' Power-of-2 to add to ADCres.

' Demonstration loop: take a conversion, display it, and loop.
again:
  gosub ADconvert      ' Perform conversion.
  debug ADCres         ' Display it.
goto again             ' Do it again.

' ADC conversion routine.
ADconvert:
  ADCres = 0: pwrTwo = 128
convLoop:
  ADCres = ADCres + pwrTwo   ' Add current power-of-2 to ADCres
  PWM refOut,ADCRes,1        ' ..and output that voltage via PWM.
  if comp_p = 1 then skip1   ' If unknown voltage is lower, then
  ADCRes = ADCres-pwrTwo     ' subtract power-of-2 from ADCres.
skip1:
  pwrTwo = pwrTwo/2          ' Try next lower power-of-2..
  if pwrTwo <> 0 then convLoop ' ..until power-of-2 = 0
return
```

Listing 3. Improved Comparator ADC for BS2

```
' Program: COMP_AD2.BS2
' (Binary-search ADC with the BS2 and a comparator)
' This program implements an ADC using a comparator.
' The unknown voltage goes to the comparator's + input and the
' Stamp's PWM output to the - input. The Stamp systematically
' searches for the unknown voltage by splitting the possible
' range of voltages in half, seeing whether the unknown is
' higher or lower, then splitting that range in half ...
' This approach assures that the conversion is always
' finished in the shortest time possible. The conversion
' subroutine presented here runs at about 37 conversions/second.

refOut  con   0      ' Comparator reference.
comp_pvar     in1    ' Comparator output (pin).
ADCresvar     byte   ' Analog-to-digital result.
pwrTwo var    byte   ' Power-of-2 to add to ADCres.

' Demonstration loop: take a conversion, display it, and loop.
again:
  gosub ADconvert      ' Perform conversion.
  debug ? ADCres       ' Display it.
goto again             ' Do it again.

' ADC conversion routine.
ADconvert:
  ADCres = 0: pwrTwo = 128
convLoop:
  ADCres = ADCres + pwrTwo   ' Add current power-of-2 to ADCres
  PWM refOut,ADCRes,1        ' ..and output that voltage via PWM.
  if comp_p = 1 then skip1   ' If unknown voltage is lower, then
  ADCRes = ADCres-pwrTwo     ' subtract power-of-2 from ADCres.
skip1:
  pwrTwo = pwrTwo >> 1       ' Try next lower power-of-2..
  if pwrTwo <> 0 then convLoop ' ..until power-of-2 = 0
return
```

Listing 4. Total-Shutdown Voltage Regulator for BS1

```
' Program: TURNOFF.BAS
' (BS1 controls LP2951 regulator for system shutdown)
' This program demonstrates how the Stamp can use a shutdown-
' capable power supply to provide push-on/auto-off power
' control. In this type of operation, the user presses a button,
' putting a low on the LP2951 shutdown pin and supplying 5 volts
' to the system. This starts up the Stamp, which immediately
' puts a low on the shutdown pin itself. This latches the power
' supply on after the user releases the button. The process takes
' only 20 ms, so even a brief button press will do. When the
' Stamp's work is done, it shuts itself (and everything else
' on the same power supply) off by putting a high on the shutdown
' pin. The supply remains off until the button is pressed again.
' If you have the Stamp powered by the LP2951, remember that you
' will have to hold the ON button down throughout downloading.
' Also, you may find that this program will not start up normally
' unless the Stamp programming cable is removed.

SYMBOL powerControl =    0      ' LP2951 shutdown pin.
SYMBOL LEDoutput    =    7      ' LED output for demo.

PowerOn:
  low powerControl              ' Latch power supply ON.

'=====================================================
' Substitute your own code for the LED flasher below.
for b2 = 1 to 20 ' Flash LED 10 on/off cycles.
  toggle LEDoutput              ' Toggle the LED.
  w2 = 700/b2                   ' W2 sets delay that decreases..
  pause w2                      ' ..with each cycle.
next
'=====================================================

PowerOff:
  high powerControl             ' Turn power (and Stamp) OFF.
```

Sources

For more information on the BASIC Stamp, contact:

Parallax, Inc.
3805 Atherton Road, #102, Rocklin, CA 95765
phone **(916) 624-8333**
Internet **http://www.parallaxinc.com**

The ICs mentioned in this article are available from:

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fax **415-592-2503** or **800-237-6948**.
Part numbers are 107203 (LP2951) and 23851 (LM339).

Scott Edwards Electronics carries the LTC1298 AppKit mentioned in this article. This package shows users of Stamps (1 and 2) and PICs (using Parallax assembly language) how to interface the LTC1298 12-bit ADC. It includes printed documentation, source code on disk, and an LTC1298 chip for $25.00.

For a catalog of serial LCDs and Stamp-related products, contact:

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Total Shutdown

The Stamps have Nap and Sleep modes that reduce their current draw during periods of inactivity. That's fine for the Stamp, but what about external circuitry — how about turning it off too?

That's the idea behind Figure 3 and Listing 4, which arose from a question posed by a reader. He wanted his project to turn on at the touch of a button, and completely off after a period of inactivity. Many commercial products work this way, saving a lot of batteries from an early grave.

My answer is to use a National Semiconductor LP2951. This is an efficient, low-dropout regulator with a shutdown pin (pin 3 in the figure, labeled Off). When this pin is high, the regulator shuts down; when it's low, the regulator turns on. When the user presses the ON button shown in the schematic, the LP2951 supplies regulated 5 volts to the system.

Since the Stamp is powered by this 5V supply, it wakes up about 20 milliseconds after the button is pressed. It immediately applies a low to the shutdown pin to hold the power supply on. When the user releases the button, the circuit remains powered.

When the Stamp's work is done, it applies a high to the shutdown pin, immediately cutting 5V power to the circuit. In shutdown, the regulator draws just a few 10s of microamps, mostly through the 47K resistor on the shutdown pin itself. It still puts about 0.7V onto the 5V supply rail, resulting in a tiny leakage current through the rest of the circuit. In most cases, this won't cause any problems; I just mention it for those who might poke around with a meter.

The LEDs at the bottom of the schematic are to help you see the operation of the demo; they can be omitted in your final application.

After you download the demo program, remove the Stamp programming cable. Otherwise, leakage currents from the cable will prevent complete shutdown.

One capability of the LP2951 hinted at in the schematic but not shown in the demo is its error output (pin 5, marked Err). If the LP2951 experiences a problem, such as overheating, excess current draw or inadequate input voltage to maintain regulation, it will output a low on the error pin. You might experiment with monitoring this input with the Stamp as an early warning of power loss. But, in most cases, the Stamp is likely to lose consciousness before it can do anything about the warning. If you don't use the error-detect feature, you can omit the pair of 220K resistors. **NV**

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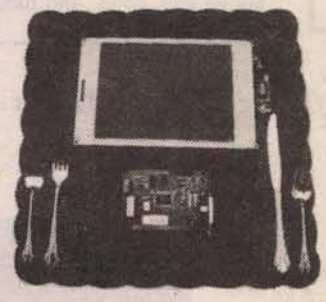

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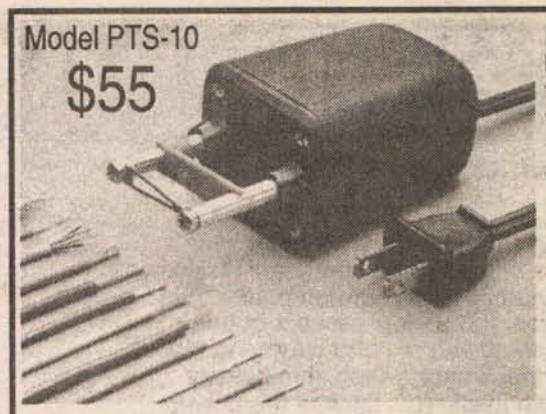

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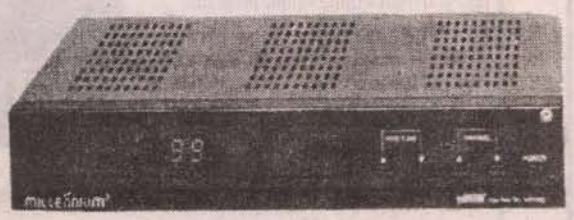

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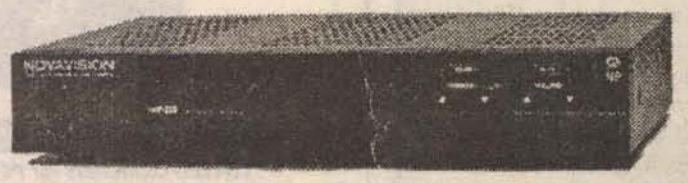

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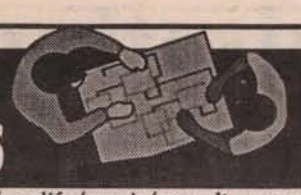

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Serial Communications and Protocol Stacks:

Why All The Layers?

Part 2

by Jeff Stefan

In Part 1 of this article, we examined the structure of protocol stacks and developed a set of low-level interrupt driven RS232 communications functions. These functions serve the Input Queue level sub-level of the Data Link Layer.

In Part 2, we will build the Message Buffer service functions and develop a Data Link protocol to transfer data packets from machine to machine.

A Little History: OSI versus TCP/IP

In the mid-70s, designers were creating proprietary computer networks. Unfortunately, none of these proprietary networks could talk reliably to each other. It soon became apparent that some kind of communications standards, or protocols, were needed to exploit the full potential of networked systems. An ISO (International Standards Organization) committee was quickly formed in 1978 to create a set of standards called Open Systems Interconnection, thus coining the acronym OSI. After about 18 months, the Reference Model for Open Systems Interconnection was complete. The result is the Seven Layer Model, as illustrated in Figure 1.

The developers of OSI were concerned primarily with the Reference Model architecture, and less concerned with protocols. The OSI architecture has deep roots in telecommunications, and was not tailored specifically for computer-to-computer communications. Figure 2 contains an overview of each of seven layers.

While political battles occurred over OSI, the government was quietly concerned about how systems would continue to communicate in the event of a nuclear war or other catastrophic national disaster. The Department of Defense sponsored a research network called the ARPANET, which stands for the Advanced Research Projects Agency Network.

The ARPANET rapidly expanded throughout universities and government agencies. ARPANET developers were more concerned with actual protocols rather than focusing on a formal architecture. From their research came two primary protocols: TCP, which stands for Transport Control Protocol; and IP, which stands for Internet Protocol. From these protocols an architecture emerged, called the TCP/IP Reference Model. Computer networks were now communicating reliably, and over great distances. Real work was being done. The TCP/IP reference model is shown in Figure 3.

The TCP/IP Reference Model contains less layers than the OSI model. That's because the OSI Session and Presentation Layers were inserted into the model to be compatible with IBM's System Network Architecture, or SNA. These layers are seldom used in practice, so the TCP/IP designers left them out. The TCP and UDP protocols are located in the Transport Layer, and the IP is located in the Network Layer. UDP stands for User Datagram Protocol. From this model, the Internet was built.

Frame Format

Our protocol stack model contains four layers, as illustrated in Figure 4.

Our focus is on the Data Link Layer. The Data Link Layer is divided into two sub-layers, called the Input Queue and the Message Buffer. The functions developed in Part 1 of this article write bytes and read bytes to and from a serial port. These functions provide the lowest level of services in the Data Link Layer. The Message Buffer layer functions build on these lower level services to send and receive frames. The functions associated with each of the sub-layers are illustrated in Figure 5.

The raw byte stream provided by the Input Queue sub-layer isn't good enough for reliable machine-to-machine communications. The byte stream needs to be assembled into meaningful packets, or frames. By building frames, the upper layer functions can check the integrity of the data transmission and reliably extract meaningful information from the frame. The frame format we will use is shown in Figure 6.

The frame is constructed from three components: the Header, Payload Data, and Trailer. The frame is defined by a set of three C structures as shown in Figure 7.

The Header and Data segments are defined in separate structures, then merged into one structure called FRAME. This makes it easier to experiment with the header and data segments. It also makes it easier to write functions that act only on the header, and only on the data.

Checksums

The error checking method we will employ is a simple checksum. Here's how it works. As the sender builds a packet, the bytes are added up, then every bit is inverted. The inverted sum is placed in the last byte. When the receiver gets the packet, it adds the bytes, then performs an exclusive "or" operation using the bytes it added and the inverted sum in the packet. If the result is FFh (all ones), then the packet is good. If the packet is not all ones, then an error occurred and it must be re-transmitted. An example of how this works is shown in Figure 8.

How is the sum inverted by the Sender? It's easy in C. All you have to do is use the one's complement operator, which is the tilde. Once the bytes are added, the line of code to accomplish this is:

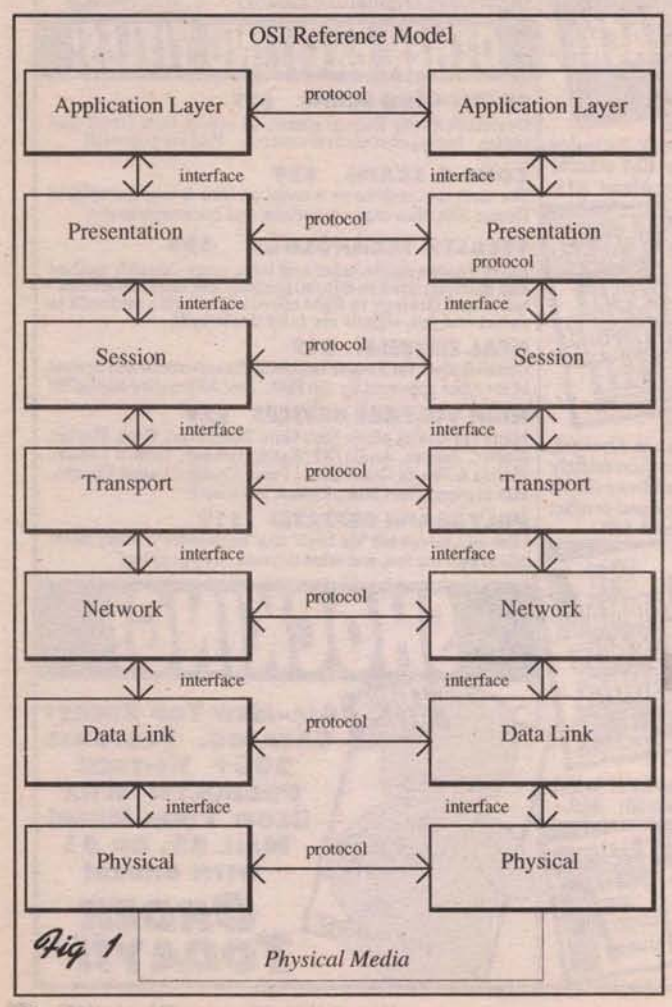

Fig 1

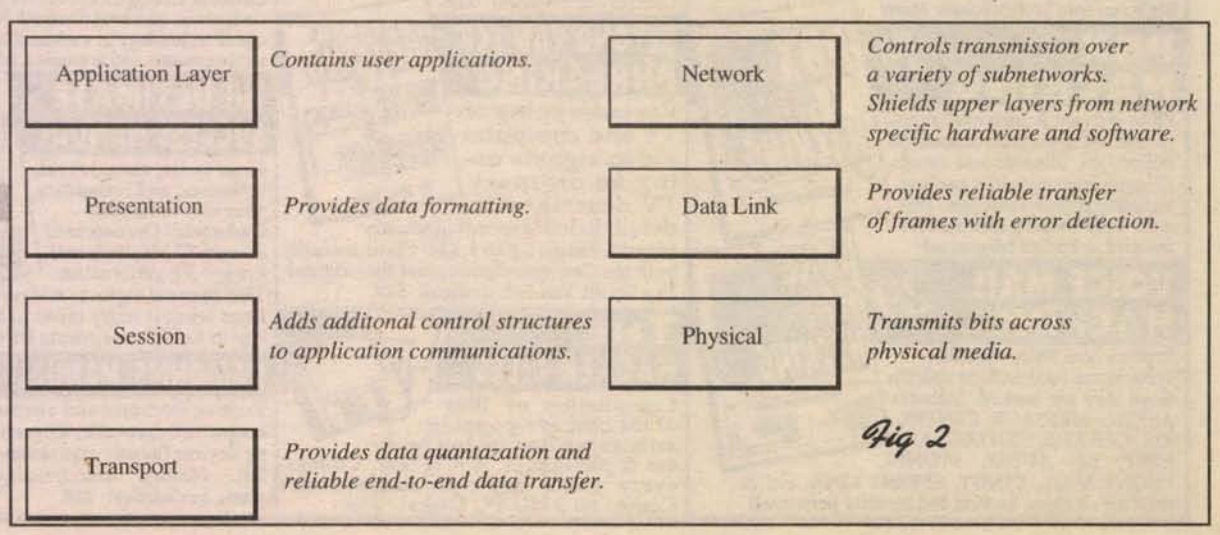

Fig 2

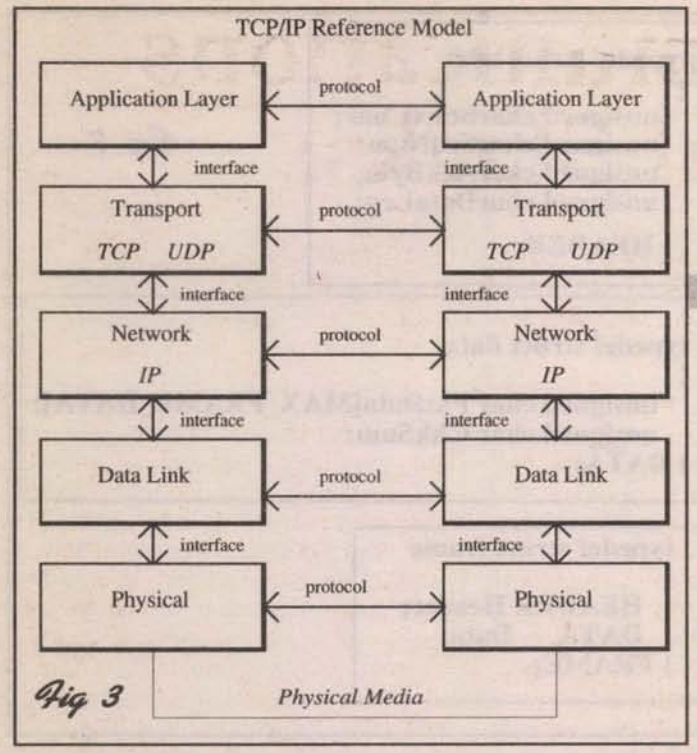

Fig 3

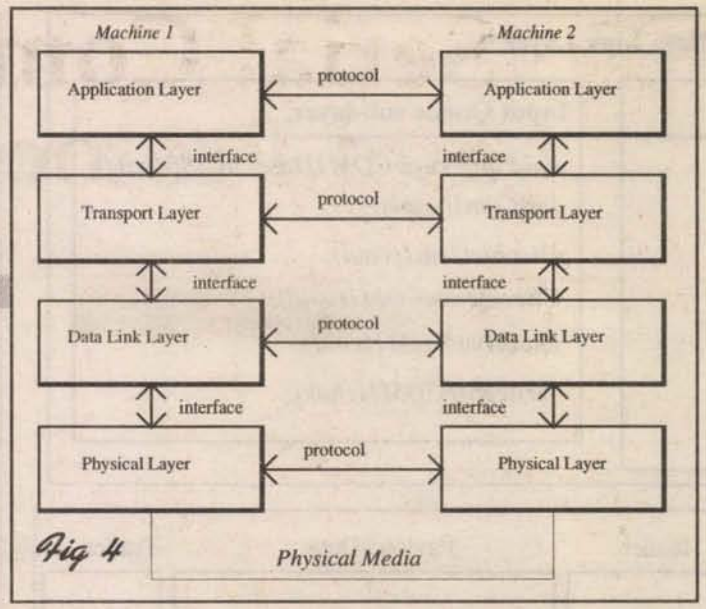

Fig 4

Chksum = ~(Chksum);

Cyclic Redundancy Checks

Cyclic Redundancy Checks, or CRCs, are the most effective way of detecting transmission packet errors. CRCs are commonly implemented in hardware. CRCs are based on frame check sequences, which can be generated from data packets. The frame check sequence is sometimes referred to as a polynomial generator. Frames and frame sequences are viewed as polynomials. For example, the frame 10110111 is represented as x7 + x5 + x3 + x2 + x1 + 1. The frame check sequence 10101 is represented as x4 + x2 + 1.

Here's how CRCs work: The frame is divided by the frame check sequence, and the remainder tacked on to the end of the frame. The frame is then transmitted. Both the sender and receiver agree in advance on the frame check sequence. When the receiver gets the frame, it divides the frame by the frame check sequence. If the result is zero, then the packet contains no errors. There are three commonly used frame check sequences, as shown in Figure 9.

Packet Structure

In this section, we'll construct the transmission frames, or packets. For our purposes, the term frame and packet are interchangeable. The function used to build a packet (or frame) is called BuildFrame (unsigned char *DataToSend). This function performs eight clearly defined steps. These steps are:

1. Increment the packet sequencecounter.
2. Load the packet data (that's the DataToSend character array passed to the function).
3. Set the ACK byte to zero.
4. Calculate the packet length.
5. Load the length byte.
6. Load the start character ':'.
7. Calculate the packet checksum.
8. Load the checksum byte.

These steps are short and simple. Refer to BuildFrame (DataToSend) in the program listing for DL1.C for the details. After this function is called, the Frame structure is loaded and ready for transmission. Figure 10 illustrates a completed frame with data 12345 loaded into the Frame.Data.PktData array. These are the bytes you will see if you build and transmit this frame.

As you build frames, the Sequence Number will increment each time, allowing the receiving side to track the frames. Building and sending frames is easier than detecting and processing frames.

Once the frame is sent, the receiver must extract the frame from the message buffer. Remember our data link layer is broken into two subsections: the Input Queue, which contains raw characters received from the physical layer; and the Message Buffer, which contains packets or frames.

The Protocol

The protocol presented here is a simple Stop and Wait protocol. A Stop and Wait protocol sends a frame, then waits for a response packet. No other communication occurs when the sender is waiting for a response packet. The commu-

```
/*****************************************************
* Filename    : dl1.h
* Description : Data Link Layer serial communi-
* cations header file.
*
* Notes: This file contains the #defines and
* data structures used to create, receive, and
* transmit frames.
*
*
* (c) 1997 Jeff Stefan
*
*****************************************************
*/
#define TIME_OUT_VAL  1000

#define MAX_FRAME_DATA  256
#define MAX_BUFFER_SIZE 1024
#define HEADER_SIZE 4
#define ACK 0x06
#define NAK 0x15

/*********************
* Header structure
*********************/
typedef struct hdr
{
  unsigned char StartChar;
  unsigned char SeqNum;
  unsigned char FrameLen;
  unsigned char AckByte;
}HEADER;

/*********************
* Data structure
*********************/
typedef struct data
{
  unsigned char PktData[MAX_FRAME_DATA];
  unsigned char ChkSum;
}DATA;

/*********************************************
* Frame structure built from HEADER and
DATA
*********************************************/
typedef struct frame
{
 HEADER Header;
 DATA  Data;
}FRAME;
```

```
/*****************************************
* Filename    : datalink.h
* Description : #defines for datalink.c
*
*****************************************/

/*******************
* COM port defines
*******************/
#define COM1 0x3f8
#define COM2 0x2f8
#define COM3 0x3e8
#define COM4 0x2e8

/*********************
* Interrupt requests
*********************/
#define IRQ_3  0x0b
#define IRQ_4  0x0c

/*******************************
* PIC address and mask values
* for INT3 and INT4.
*******************************/
#define PIC         0x21
#define EOI         0x20
#define IRQ3_MASK    0xf7
#define IRQ4_MASK    0xef
#define DISABLE_IRQ3 0x00
#define DISABLE_IRQ4 0x10

/*******************
* Register defines
*******************/
#define COM1_INT_ENAB_REG   COM1+1
#define COM1_INT_ID_REG     COM1+2
#define COM1_LINE_CTRL_REG  COM1+3
#define COM1_MODEM_CTRL_REG COM1+4
#define COM1_LINE_STAT_REG  COM1+5
#define COM1_MODEM_STAT_REG COM1+6

#define COM2_INT_ENAB_REG   COM2+1
#define COM2_INT_ID_REG     COM2+2
#define COM2_LINE_CTRL_REG  COM2+3
#define COM2_MODEM_CTRL_REG COM2+4
#define COM2_LINE_STAT_REG  COM2+5
#define COM2_MODEM_STAT_REG COM2+6

#define COM3_INT_ENAB_REG   COM3+1
#define COM3_INT_ID_REG     COM3+2
#define COM3_LINE_CTRL_REG  COM3+3
#define COM3_MODEM_CTRL_REG COM3+4
#define COM3_LINE_STAT_REG  COM3+5
#define COM3_MODEM_STAT_REG COM3+6

#define COM4_INT_ENAB_REG   COM4+1
#define COM4_INT_ID_REG     COM4+2
#define COM4_LINE_CTRL_REG  COM4+3
#define COM4_MODEM_CTRL_REG COM4+4
#define COM4_LINE_STAT_REG  COM4+5
#define COM4_MODEM_STAT_REG COM4+6

/*********************************
* Baudrate, databits, stopbits,
* and parity values
*********************************/
#define SET_DLAB        0x80

#define BAUD_300        0x180
#define BAUD_1200       0x60
#define BAUD_2400       0x30
#define BAUD_4800       0x18
#define BAUD_9600       0x0c
#define BAUD_192K       0x06

#define FIVE_DATA_BITS   0x00
#define SIX_DATA_BITS    0x01
#define SEVEN_DATA_BITS  0x02
#define EIGHT_DATA_BITS  0x03

#define ONE_STOP_BIT     0x00
#define TWO_STOP_BITS    0x04

#define NO_PARITY        0x00
#define ODD_PARITY       0x08
#define EVEN_PARITY      0x18
#define MARK             0x28
#define SPACE            0x38

#define BREAK            0x00
#define NO_BREAK         0x40

/*******************
* Misc Defines
*******************/
#define SET_RxRDY       0x01
#define INT_PENDING     0x01
#define CHAR_IN_UART    0x04
#define XMIT_BUF_EMPTY  0x02
#define MAX_QUEUE_SIZE  1024
```

Program listing from Part 1

Fig 5

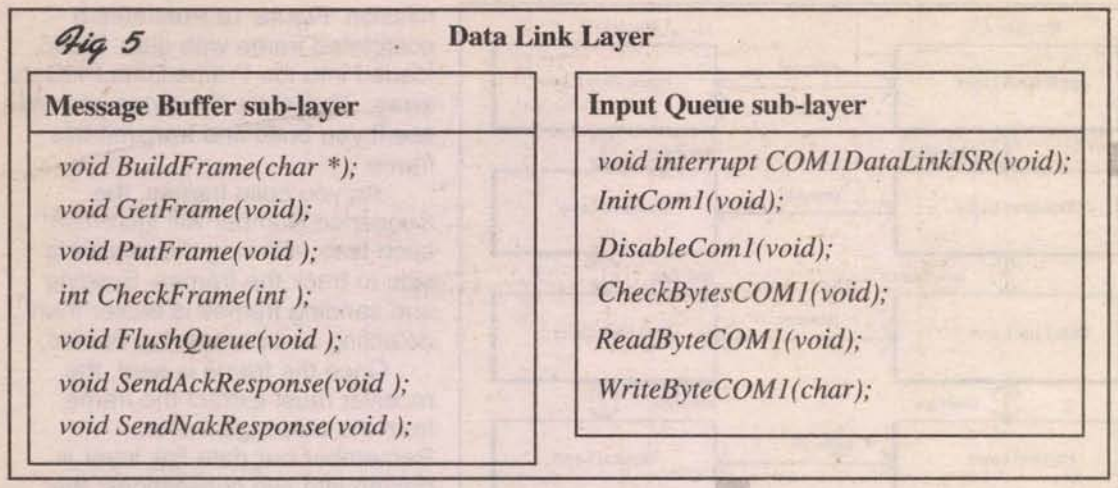

Fig 7

```
typedef struct hdr
{
   unsigned charStartChar;
   unsigned charSeqNum;
   unsigned charAckByte;
   unsigned charDataLen;
 } HEADER;
```

```
typedef struct data
{
   unsigned char PktData[MAX_FRAME_DATA];
   unsigned char ChkSum;
} DATA;
```

```
typedef struct frame
{
   HEADER Header;
   DATA    Data;
 } FRAME;
```

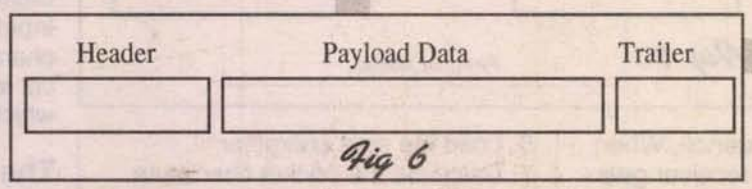

Fig 6

nications flow is illustrated in Figure 11.

The sender builds a frame and transmits it to the receiver, then waits. The receiver checks the incoming frame for errors then issues an appropriate response packet. If the received frame is bad, then the receiver issues a NAK response packet. This means that the packet was corrupted on the way to the receiver, and that the same packet must be re-transmitted by the sender with the same sequence number. If the receiver issues an ACK response packet, then the sender is free to increment the sequence number and send the next frame.

This protocol is far from perfect, but it's a good place to start. Protocols start getting complicated in a hurry, and it's a good idea to start with something simple that works.

The Program

DL1.EXE is the executable file for our simple Stop and Wait protocol. The C source code is given in DL1.C and DL1.H. The program starts executing in Terminal Mode, and can transmit and receive characters at 19.2K baud on COM1. The best way to experiment with

```
/*****************************************************
* Filename    : dl1.c
* Description :    Data Link Layer serial communica-
* tions routines.
* Note: Compile with Large or Small Memory Model
*
* The functions in this module from datalink.c are:
*
* void interrupt DataLinkISR(void);
* void interrupt (*OldISR)(void);
* int InitCom1(void);
* int DisableCom1(void);
* int CheckBytes(void);
* int ReadByte(void);
* void WriteByte(unsigned char);
*
* New functions developed in modules are:
*
* void BuildFrame(char*);
* int GetFrame(void);
* void PutFrame(void);
* int CheckFrame(int);
* void FlushQueue(void);
* void SendAckResponse(void);
* void SendNakResponse(void);
*
* (c) 1997 Jeff Stefan
*
*****************************************************/
#include <stdio.h>
#include <stdlib.h>
#include <dos.h>
#include <bios.h>
#include <conio.h>
#include <string.h>

#include "datalink.h"
#include "dl1.h"

#define ESCAPE 0x1b
#define SUCCESS 0
#define FAILURE -1

#define DEBUG
#define HEX_DISPLAY

/*********************
* Function prototypes
*********************/
void interrupt DataLinkISR(void);
void interrupt (*OldISR)(void);
int InitCom1(void);
int DisableCom1(void);
int CheckBytes(void);
int ReadByte(void);
void WriteByte(unsigned char);
void BuildFrame(char *);
int GetFrame(void);
void PutFrame(void);
int  CheckFrame(int);
void FlushQueue(void);
void SendAckResponse(void);
void SendNakResponse(void);


/************************
* Input queue variables
************************/
unsigned char InputQueue[MAX_QUEUE_SIZE];
unsigned char
*HeadPtr,*TailPtr,*StartOfQueue,*EndOfQueue;
unsigned char PicVal=0x00;

/*********************************
* Input Message Buffer and index
*********************************/
unsigned char InputMsgBuff[MAX_QUEUE_SIZE];
int BufIdx=0;

/***********************************
* Frame declarations
***********************************/
FRAME InFrame;
FRAME OutFrame;
unsigned char Buffer[MAX_BUFFER_SIZE];
char DataToSend[128];

typedef enum MODE
{TERMINAL,SEND,RECEIVE,EXIT};
int Mode = TERMINAL;

#ifdef DEBUG
  unsigned char Dbg;
  unsigned int  DbgCnt=0;
#endif

int main()
{
int InChar    = 0x00;
int Done      = 0;
int Input     = 0;
int Selection = 0;
int FrameLen  = 0;
int Status    = 0;
int i;

  clrscr();


/*****************************************************************
**
  * Init COM1 to 9600 baud, 8 data bits, 1 stop bit, and
no parity

*****************************************************************
**/
  InitCom1();

  /*****************************
  * Init the input queue pointers
  *****************************/
  HeadPtr    = TailPtr = StartOfQueue = InputQueue;
  EndOfQueue = StartOfQueue + MAX_QUEUE_SIZE;

  /*****************************
  * Main communications loop
  *****************************/
  while(!Done)
  {
    switch(Mode)
    {
      case TERMINAL:
        while(InChar != ESCAPE)
        {
          if(kbhit())
          {
            InChar = getch();
            if(InChar != ESCAPE)
            {
              WriteByte(InChar);
            }
          }
          else
          if(CheckBytes())
          {
            ReadByte();
          }
        }

        printf("\nEnter Mode: 0 = TERMINAL, 1 = SEND,
2 = RECEIVE 3 = EXIT\n");
        scanf("%d",&Input);
        switch(Input)
        {
          case TERMINAL:
            clrscr();
            InChar = NULL;
            break;

          case SEND:
#ifdef DEBUG
            printf("PacketData is: %s\n",DataToSend);
#endif
            clrscr();
            printf("—— Build and Send Packet ——\n");
```

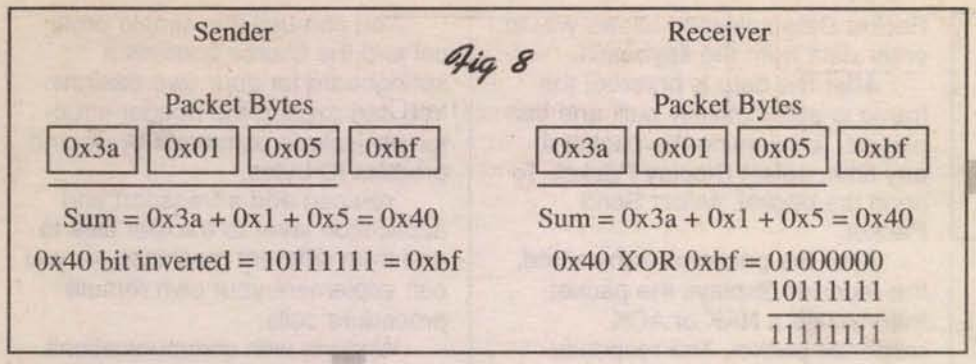

Fig 8

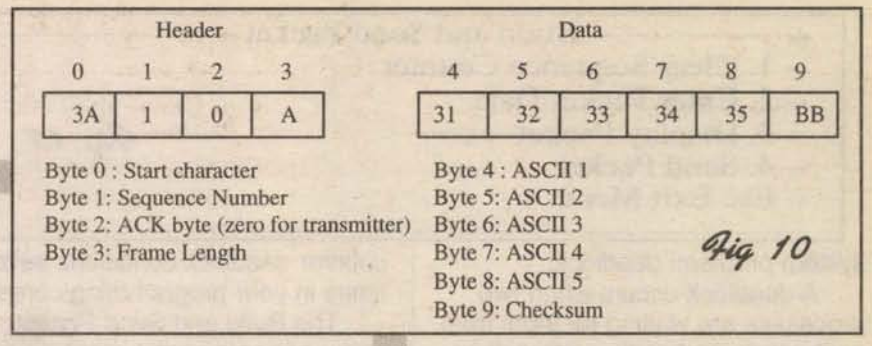

Fig 10

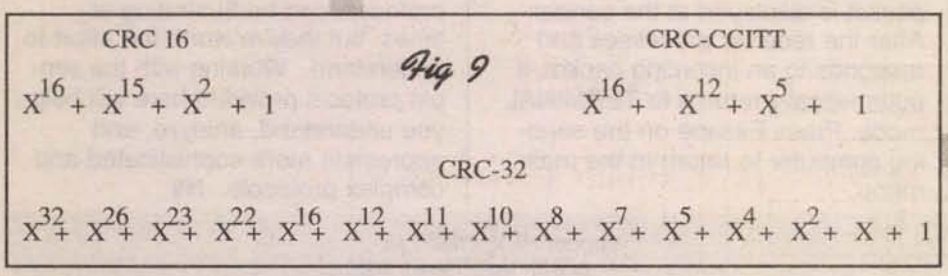

Fig 9

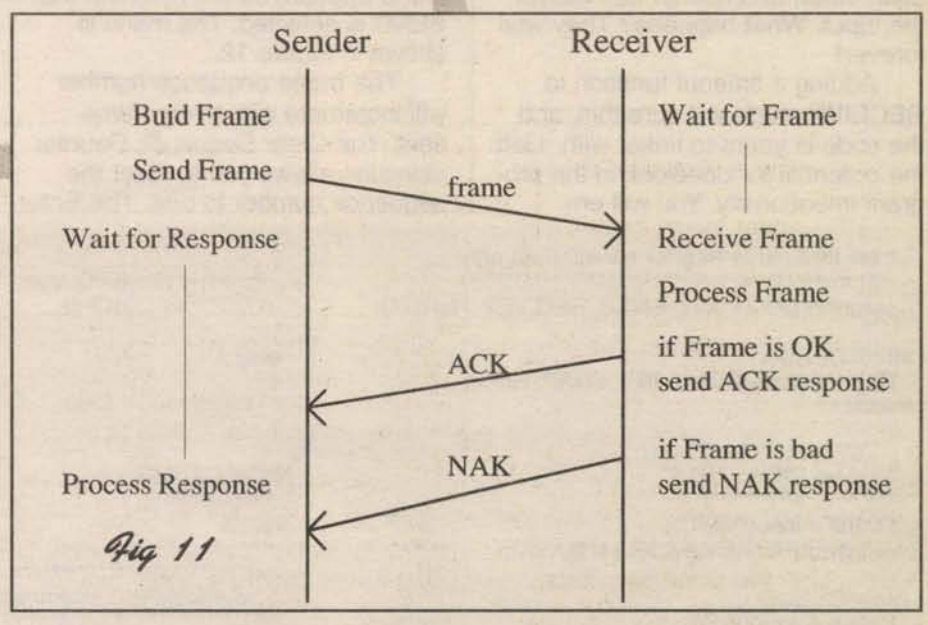

Fig 11

the protocol is to run DL1.EXE on two machines connected with a three wire cable on COM1. (The cable diagrams were listed in Part 1 of this article.) When the Escape key is pressed, the following menu appears:

Enter Mode: 0 = TERMINAL, 1 = SEND, 2 = RECEIVE 3 = EXIT

Select SEND on one computer and RECEIVE on the other. Remember, DL1.EXE is a bare bones program and contains very little error checking. If you ask both machines to RECEIVE, you're stuck!

There are no timeouts added to RECEIVE mode. This is a classic example of an interprocess communications and multitasking operating

```
        printf("— 1. Clear Sequence Counter  —\n");
        printf("— 2. Enter Packet Data       —\n");
        printf("— 3. Display Packet          —\n");
        printf("— 4. Send Packet             —\n");
        printf("— Esc Exit Menu              —\n");
        printf("————————————————————————————\n");

        Selection = getch();
        switch(Selection)
        {
         /*************************
         * Clear sequence counter
         *************************/
         case '1':
          clrscr();
          OutFrame.Header.SeqNum = 0x00;
          printf("Sequence Number Cleared\n");
          printf("\nPress Esc...\n");
          break;

         /*********************
         * Enter packet data
         *********************/
         case '2':
          clrscr();
          printf("Enter Packet Data: \n");
          scanf("%s",DataToSend);
          BuildFrame(DataToSend);
          flushall();
          printf("\nPress Esc...\n");
          break;

         case '3': // display packet
          clrscr();
                printf("OutFrame.Header.StartChar =
[%X]\n",OutFrame.Header.StartChar);
          printf("OutFrame.Header.SeqNum    =
[%X]\n",OutFrame.Header.SeqNum);
          printf("OutFrame.Header.AckByte   =
[%X]\n",OutFrame.Header.AckByte);
          printf("OutFrame.Header.FrameLen  =
[%X]\n",OutFrame.Header.FrameLen);

          printf("OutFrame.Data.PktData =
%s\n",OutFrame.Data.PktData);
          printf("OutFrame.Data.ChkSum  =
[%X]\n",OutFrame.Data.ChkSum);
          break;

         case '4':  // send packet
          clrscr();
          PutFrame();

          /*********************
          *  get response frame
          *********************/
          while(!(CheckBytes()))
           ;
          FrameLen = GetFrame();
          Status = CheckFrame(FrameLen);
          break;

         default:
          break;
        }
        InChar = NULL;
        break;

       case RECEIVE:
        printf("Receiving.....\n");
        while(!(CheckBytes()))
          ;
        FrameLen = GetFrame();
        Status = CheckFrame(FrameLen);
        if(Status == SUCCESS)
        {
         SendAckResponse();
        }
        else
        {
         SendNakResponse();
        }

#ifdef DEBUG
        printf("\nExiting RECEIVE case\n");
#endif
        InChar = NULL;
        break;

       case EXIT:
        Done = 1;
        break;

       default:
        break;
       }
      break;

      default:
       break;
    }
   }
  DisableCom1();

#ifdef DEBUG
   printf("Debug Count = %d\n",DbgCnt);
#endif

  return(0);
  }

/*************************************************************
*: InitComPort : initializes COM port.
*
*************************************************************/
int InitCom1()
{
unsigned char PortData;

 /************************************
 * Set Line Control Register DLAB bit 7
 * to enable baudate initialization.
 ************************************/
 PortData = inportb(COM1_LINE_CTRL_REG);
 outportb(COM1_LINE_CTRL_REG, SET_DLAB |
PortData);

#ifdef DEBUG
 Dbg = inportb(COM1_LINE_CTRL_REG);
#endif

 /************************************
 * Write baudrate value to Reg0 and Reg1
 ************************************/
 outport(COM1,BAUD_192K);

 /************************************************
 * save the old interrupt service routine at INT4
 ************************************************/
 OldISR = getvect(IRQ_4);

 /************************************
 * use setvect() to point to com ISR
 ************************************/
 setvect(IRQ_4,DataLinkISR);

 /************************************
 * Setup Line Control Reg for eight data
 * bits, one stop bit, and no parity.
 ************************************/

outportb(COM1_LINE_CTRL_REG,EIGHT_DATA_BIT
S |
       ONE_STOP_BIT | NO_PARITY);

#ifdef DEBUG
  Dbg = inportb(COM1_LINE_CTRL_REG);
#endif

 /************************************
 * Set the Modem Control Register
 ************************************/
 outportb(COM1_MODEM_CTRL_REG,0x0b);

 /************************************************
```

```
---------- Build and Send Packet ----------
-- 1. Clear Sequence Counter
-- 2. Enter Packet Data
-- 3. Display Packet
-- 4. Send Packet
-- Esc Exit Menu
-------------------------------------------
```

Fig 12

system problem: deadlock.

A deadlock occurs when two processes are waiting for input from each other, and neither can deliver the input. What happens? They wait forever!

Adding a timeout function to RECEIVE mode will cure this, and the code is yours to tinker with. I left the potential for deadlock in the program intentionally. You will encounter deadlock conditions several times in your programming career.

The Build and Send Packet menu appears on the machine that SEND is selected. The menu is shown in Figure 12.

The frame sequence number will increment with every frame sent. The Clear Sequence Counter selection allows you to reset the sequence number to one. The Enter Packet Data selection allows you to enter data from the keyboard.

After the data is entered, the frame is automatically built and displayed. To examine the packet at any time, select Display Packet. To send the packet, select Send Packet.

After the packet is transmitted, the receiver displays the packet, then issues a NAK or ACK response packet. The response packet is displayed at the sender. After the receiver processes and responds to an incoming packet, it automatically returns to TERMINAL mode. Press Escape on the sending computer to return to the main menu.

You can use this simple protocol and the source code as a springboard for your own designs. You can expand the header structure to include command bytes and process ID bytes.

You can add a transport and application layer to transfer files to and from different machines, or you can implement your own remote procedure calls.

Working with communications protocols can be frustrating at times, but they're worth the effort to understand. Working with the simple protocol provided here will help you understand, analyze, and appreciate more sophisticated and complex protocols. **NV**

```
  * set Int Enable Reg for rcv interrupt only
  ********************************************/
  outportb(COM1_INT_ENAB_REG,SET_RxRDY);

#ifdef DEBUG
  Dbg = inportb(COM1_INT_ENAB_REG);
#endif

  /***********************
  * set up PIC for INT4
  ***********************/
  PicVal = inportb(PIC);
  outportb(PIC,PicVal & IRQ4_MASK);

#ifdef DEBUG
  Dbg = inportb(PIC);
#endif

  /*************************************
  * read char from port to flush input
  *************************************/
  inportb(0x3f8);

#ifdef DEBUG
  Dbg = inportb(0x3f8);
  Dbg = inportb(0x3f9);  // int enab
  Dbg = inportb(0x3fb);  // line ctrl
  Dbg = inportb(0x3fc);  // modem ctr
  Dbg = inportb(0x3fd);  // line status
  Dbg = inportb(0x3fe);  // modem status
  Dbg = inportb(0x21);   // PIC
#endif
  return(0);
}

/*************************************************************
*: DisableCom1 :  disables COM1 port.
*
*************************************************************/
int DisableCom1()
{
  /***************************************
  * restore old interrupt service routine
  ***************************************/
  setvect(IRQ_4,OldISR);

  /************************
  * restore old PIC value
  ************************/
  PicVal = inportb(PIC);
  outportb(PIC,PicVal | DISABLE_IRQ4);

#ifdef DEBUG
  Dbg = inportb(PIC);
#endif

  return(0);
}

/*************************************************************
*: DataLinkISR : serial port interrupt service routine.
*
*************************************************************/
void interrupt DataLinkISR(void)
{

unsigned char InChar;

 enable();

 InChar = inportb(COM1);
 if(TailPtr == EndOfQueue)
 {
   TailPtr = StartOfQueue;
   *TailPtr++ = InChar;
 }
 else
 {
   *TailPtr++ = InChar;
 }

#ifdef DEBUG
  DbgCnt+=1;
#endif

 /*****************************
 *  re-enable PIC interrupts
 *****************************/
 outportb(EOI,EOI);
}

/*************************************************************
*: CheckBytes : checks if queue contains unread chars. * Returns zero in no bytes in queue, else returns
* number  of chars in queue.
*************************************************************/
int CheckBytes(void)
{
  /*****************************************
  * check if head pointer == tail pointer
  * if ==, no chars are in buffer: return(0);
  * num chars = abs diff from head to tail
  * return num chars.
  *****************************************/
  if(HeadPtr - TailPtr)
  {
    return(abs(HeadPtr - TailPtr));
  }
  else
  {
    return(0);
  }
}

/*************************************************************
*: FlushQueue: Reassigns input queue head and tail pointers.
*
*************************************************************/
void FlushQueue()
{
  HeadPtr    = TailPtr = StartOfQueue = InputQueue;
  EndOfQueue = StartOfQueue + MAX_QUEUE_SIZE;
}

/*************************************************************
*: ReadByte : reads a byte from the queue
*
*************************************************************/
int ReadByte(void)
{
int ByteCount=0;
  /*****************************************
  * check if head pointer == tail pointer
  * if ==, no chars are in buffer: return(0);
  *****************************************/
  if(HeadPtr >= TailPtr)
  {
    HeadPtr = StartOfQueue;
    return(0);
  }
  else
  {
#ifndef HEX_DISPLAY
    printf("%c",*HeadPtr);
#endif
#ifdef HEX_DISPLAY
    printf("[%X]",*HeadPtr);
#endif

  HeadPtr++;
  }
  return(0);
}

/*************************************************************
* WriteByte : writes a byte out the serial port
*
*************************************************************/
void WriteByte(unsigned char CharToSend)
{
 /*************************************
 * Wait for the transmit flag to clear
 *************************************/
 while((inportb(COM1_LINE_STAT_REG) & 0x20) ==
0)
 {
 ;
 }
 /*****************
 * Output the byte
 *****************/
 outportb (COM1,CharToSend);
}

/*************************************************************
*: BuildFrame: builds a frame to send from a buffer.
*
*************************************************************/
void BuildFrame(char DataToSend[])
{
int PktLen = 0x00;
int ChkSum = 0x00;
int i;
char *ptr;

  /************************************
  * increment packet sequence number
  ************************************/
  OutFrame.Header.SeqNum+=1;

  /************************
  * set ACK byte to zero
  ************************/
  OutFrame.Header.AckByte = 0x00;

  /*********************
  * load packet data
  *********************/
  strcpy(OutFrame.Data.PktData,DataToSend);

  /*****************************
  * calculate packet length
  *****************************/
  ptr = OutFrame.Data.PktData;
  while(*ptr++)
  {
    PktLen+=1;
  }
  /**********************
  * add checksum byte
  **********************/
  PktLen+=1;

  /**********************
```

```
  * add header length
  *********************/
  PktLen+=HEADER_SIZE;

  /*********************
  * load length byte
  *********************/
  OutFrame.Header.FrameLen = (unsigned
char)PktLen;

  /************************
  * load start character
  ************************/
  OutFrame.Header.StartChar = ':';

  /************************
  * calculate checksum
  ************************/
  ChkSum = OutFrame.Header.StartChar;
  ChkSum+= OutFrame.Header.SeqNum;
  ChkSum+= OutFrame.Header.AckByte;
  ChkSum+= OutFrame.Header.FrameLen;

  /*****************************
  * add packet data checksum
  *****************************/
  for(i=0;i<PktLen - HEADER_SIZE;i++)
  {
    ChkSum+= OutFrame.Data.PktData[i];
  }
  ChkSum = ~(ChkSum);
  OutFrame.Data.ChkSum = ChkSum;

#ifdef DEBUG
  printf("\nOutFrame.Header.StartChar =
[%X]\n",OutFrame.Header.StartChar);
  printf("OutFrame.Header.SeqNum    =
[%X]\n",OutFrame.Header.SeqNum);
  printf("OutFrame.Header.FrameLen  =
[%X]\n",OutFrame.Header.FrameLen);
  printf("OutFrame.Header.AckByte   =
[%X]\n",OutFrame.Header.AckByte);

  printf("OutFrame.Data.PktData =
%s\n",OutFrame.Data.PktData);
  printf("OutFrame.Data.ChkSum  =
[%X]\n",OutFrame.Data.ChkSum);
#endif
}

/*************************************************************
*: GetFrame: Builds a frame from an incoming byte
stream.
*
*************************************************************/
int GetFrame()
{
unsigned char *ptr;
int i = 0x00;
int DataLen=0;
int Ctr;

  while(CheckBytes())
  {
    ReadByte();
  }
  /***************************************
  * transfer input queue to InputMsgBuff[]
  ***************************************/
  ptr = InputQueue;

  /************************
  * check for start char
  ************************/
  if(*ptr == ':')
  {
    /*******************
    * load start char
    *******************/
    InputMsgBuff[i++] = *ptr++;

    /************************
    * load sequence number
    ************************/
    InputMsgBuff[i++] = *ptr++;

    /*****************
    * load ACK byte
    *****************/
    InputMsgBuff[i++] = *ptr++;

    /*********************
    * load frame length
    *********************/
    InputMsgBuff[i++] = *ptr;
    DataLen = (int)*ptr;
    ptr++;

    /*********************
    * load data segment
    *********************/
    for(Ctr=(HEADER_SIZE+1);Ctr<DataLen;Ctr++)
    {
      InputMsgBuff[i++] = *ptr++;
    }
    /*******************
    * load checksum
    *******************/
    InputMsgBuff[i++] = *ptr;
  }
  else
  {
    DataLen = -1;
#ifdef DEBUG
    printf("Bad Packet Received!!\n");
#endif
    /*********************
    * Flush InputQueue
    *********************/
    FlushQueue();
  }
  return(DataLen);
}

/*************************************************************
*: PutFrame: Calls WriteByte() to output a frame to a
serial
*          port.
*************************************************************/
void PutFrame()
{
int i;
  /*******************
  * write header
  *******************/
  WriteByte(OutFrame.Header.StartChar);
  WriteByte(OutFrame.Header.SeqNum);
  WriteByte(OutFrame.Header.AckByte);
  WriteByte(OutFrame.Header.FrameLen);

  /*********************
  * write data
  *********************/
  for(i=0;i<OutFrame.Header.FrameLen -
(HEADER_SIZE+1);i++)
  {
    WriteByte(OutFrame.Data.PktData[i]);
  }
  WriteByte(OutFrame.Data.ChkSum);
}

/*************************************************************
*: CheckFrame: Checks a frame's checksum byte.
*
*************************************************************/
int CheckFrame(int FrameLen)
{
unsigned char ChkSum=0;
unsigned char PktChkSum=0;
int Result=0;
int i;
char *ptr;

  ptr = InputMsgBuff;
  for(i=0;i<FrameLen-1;i++)
  {
    ChkSum += *ptr++;
  }
  PktChkSum = *ptr;
  Result = ChkSum ^ PktChkSum;
  if(Result != 0xff)
  {
    Result = FAILURE;
  }
  else
  {
    Result = SUCCESS;
    InFrame.Header.SeqNum = InputMsgBuff[1];
  }
  return(Result);
}

/*************************************************************
*: SendAckResponse: Builds and sends an ACK frame.
*
*************************************************************/
void SendAckResponse()
{
int PktLen = 0x00;
int ChkSum = 0x00;
int i;
char *ptr;

  OutFrame.Header.SeqNum =
InFrame.Header.SeqNum;
  OutFrame.Header.AckByte = ACK;
  PktLen+=1;
  PktLen+=HEADER_SIZE;
  OutFrame.Header.FrameLen = (unsigned
char)PktLen;
  OutFrame.Header.StartChar = ':';

  ChkSum = OutFrame.Header.StartChar;
  ChkSum+= OutFrame.Header.SeqNum;
  ChkSum+= OutFrame.Header.AckByte;
  ChkSum+= OutFrame.Header.FrameLen;
  ChkSum = ~(ChkSum);
  OutFrame.Data.ChkSum = ChkSum;

#ifdef DEBUG
  printf("\nOutFrame.Header.StartChar =
[%X]\n",OutFrame.Header.StartChar);
  printf("OutFrame.Header.SeqNum    =
[%X]\n",OutFrame.Header.SeqNum);
  printf("OutFrame.Header.FrameLen  =
[%X]\n",OutFrame.Header.FrameLen);
  printf("OutFrame.Header.AckByte   =
[%X]\n",OutFrame.Header.AckByte);
  printf("OutFrame.Data.ChkSum  =
[%X]\n",OutFrame.Data.ChkSum);
#endif

  WriteByte(OutFrame.Header.StartChar);
  WriteByte(OutFrame.Header.SeqNum);
  WriteByte(OutFrame.Header.AckByte);
  WriteByte(OutFrame.Header.FrameLen);
  WriteByte(OutFrame.Data.ChkSum);

#ifdef DEBUG
  printf("\nACK Response Sent\n");
#endif
}

/*************************************************************
*: SendNakResponse: Builds and sends a NAK frame.
*
*************************************************************/
void SendNakResponse()
{
int PktLen = 0x00;
int ChkSum = 0x00;
int i;
char *ptr;

  OutFrame.Header.SeqNum =
InFrame.Header.SeqNum;
  OutFrame.Header.AckByte = NAK;
  PktLen+=1;
  PktLen+=HEADER_SIZE;
  OutFrame.Header.FrameLen = (unsigned
char)PktLen;
  OutFrame.Header.StartChar = ':';

  ChkSum = OutFrame.Header.StartChar;
  ChkSum+= OutFrame.Header.SeqNum;
  ChkSum+= OutFrame.Header.AckByte;
  ChkSum+= OutFrame.Header.FrameLen;
  ChkSum = ~(ChkSum);
  OutFrame.Data.ChkSum = ChkSum;

#ifdef DEBUG
  printf("\nOutFrame.Header.StartChar =
[%X]\n",OutFrame.Header.StartChar);
  printf("OutFrame.Header.SeqNum    =
[%X]\n",OutFrame.Header.SeqNum);
  printf("OutFrame.Header.FrameLen  =
[%X]\n",OutFrame.Header.FrameLen);
  printf("OutFrame.Header.AckByte   =
[%X]\n",OutFrame.Header.AckByte);
  printf("OutFrame.Data.ChkSum  =
[%X]\n",OutFrame.Data.ChkSum);
#endif

  WriteByte(OutFrame.Header.StartChar);
  WriteByte(OutFrame.Header.SeqNum);
  WriteByte(OutFrame.Header.AckByte);
  WriteByte(OutFrame.Header.FrameLen);
  WriteByte(OutFrame.Data.ChkSum);

#ifdef DEBUG
  printf("\nNAK Response Sent\n");
#endif
}
```

ELECTRONIC TEST EQUIPMENT BOUGHT & SOLD

Ailtech 360D11, Frequency Syn. .01-2GHz	$1,000
Anritsu ME645A, Microwave Radio Test Set	$1,000
Argosystems AS210, Frequency Calibration System	$3,500
Bafco 911A, Frequency Response Analyzer (unused)	$400
Ballantine 1627A, Scope Calib., with/acc. heads	$1,000
Boonton 25A, Power Meter Calibrator	$350
Boonton 4200, Power Meter, w/Detector, 100KHz-18GHz	$800
Boonton 42BD, Microwattmeter .2MHz-7GHz	$300
Boonton 518-A4, Q Standard	$250
Boonton 82AD, Modulation Meter	$650
Boonton 92A, RF Millivoltmeter w/Probe	$300
Bruel & Kjaer 1612, Bandpass Filter	$250
Cushman CE24B, Frequency Selective Voltmeter	$800
Datron 1062, Digital Multimeter	$650
DDC SR-400, Syncro Resolver Simulator	$400
Dolch COLT300, Logic Analyzer w/Ext. Chassis & Pods	$300
DR Thiedig MILLI-TO2, Ohmmeter, 1 Milliohm-2 Terraohms	$400
Eaton 380K11, Synthesizer, 1-2000MHz Opt. 01, 03, 183	$2,500
EIP 371, Source Locking Microwave Counter, .18GHz	$1,500
EIP 548A/05/06/08, Microwave Freq. Counter, 110GHz	$4,000
EIP 578, Source Locking Microwave Counter, Opt. 06	$4,000
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Fluke 3330B, DC Voltage, Current Calibrator	$400
Fluke 335A, DC Voltage Standard, 0-1100VDC	$600
Fluke 5100B/03/05, Calibrator	$4,000
Fluke 5200A, Programmable AC Voltage Standard HPIB	$1,600
Fluke 540B, Thermal Transfer Standard	$700
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Fluke 8505A, Digital Multimeter, AC, DC, Ohms	$400
Fluke 8921A/03, True RMS Voltmeter	$450
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HP 1744A, Scope, Storage, 100MHz, Dual Trace	$500
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HP 3320A, Frequency Synthesizer	$250
HP 3320B, Frequency Synthesizer	$350
HP 3325A, Synthesized Function Generator	$1,800
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Keithley 261, Pilo Amp. Source (unused)	$300
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Keithley 616, Digital Electrometer	$500
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Maury Micro LT105, Thermal Converter	$100
Micro-Tel SG800, Swept Signal Generator .1-18GHz	$1,000
Narda 792FF, Attenuator, 2-12.4GHz 0-20dB	$100
North Atl 540/10, Resolver Synchro Bridge	$600
Phillips 3211, Scope, 15MHz 2Ch.	$200
Phillips PM3267, Scope, 100MHz, Dual Trace	$400
PMI 1018B, Peak Power Meter	$350
PMI 1038, Network Anyz., 1MHz-26.5GHz, w/detectors	$800
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Tek T202, Scope, LCD Handheld	$500
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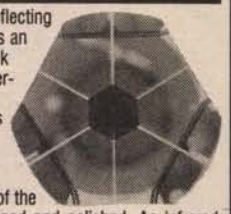

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Questions & Answers
TECH FORUM

This is a READER TO READER Column. All questions AND answers will be provided by *Nuts & Volts readers* and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and *NO GUARANTEES WHATSOEVER* are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

QUESTIONS

I want to record my pages (beeper) on a computer and printer. What kind of decoder will I need to put between a scanner and the computer? Is there software so only my pages will be recorded?

3971 **Keith Berning**
Jenera, OH

A popular and classic two-meter HT is the ICOM 02AT. Once, at a swap meet, a ham showed me his. He had done a mod to the audio. It took away that muffled sound and made it super loud. I would like to know this mod.

3972 **C. A.**
San Bernardino, CA

How can I run a Hewlett Packard Scan Jet Plus under Windows 95 or Windows 3.11, for that matter? I don't have access to www or the Internet.

3973 **K. Widdison**
via Fax

I am trying to restore a few old antennas (dish type) to be used for Direct TV reception. I need to find a manufacturer of a radio reflecting metallic coating paint to restore the reflecting surface. Can someone help me obtain a name, address, and/or telephone number of a US company where I could order a sample to experiment with?

3974 **Antonio Loreto**
Venezuela, South America
E-Mail: oretol@ven.net

I am looking for a simple CMOS circuit to flash five LEDs totally at random. (This is imperative.) I currently use a 555 as an oscillator and a 4017 decade counter/divider set at five with an interrupter circuit in between to keep it from sequencing.

3975 **Ron Morcom**
Howell, MI

How is a fluorescent tube such as those used in emergency lanterns made to operate? These small tubes are powered by 12 volts DC which would seem to be enough to light the filaments, but insufficient to jump the eight-inch gaseous track to make the phosphers glow.

3976 **L. Kenworthy KQ4MV**
Goldsboro, NC

I have an ADC LT60 linear tracking turntable that has now developed a perplexing problem.

The arm will start up normally, move to the edge of the record normally, and click down normally, but then it just stays there and doesn't move. None of the repair shops in this area want to tackle turntables (especially linear tracking) anymore. Does anyone have any idea what is wrong, and how to fix it? Has anyone ever had something similar happen to their linear tracking turntable?

3977 **Paul Mendelowitz**
Redwood City, CA

Where can I obtain a schematic and parts list in order to build a linear amplifier for my ham rig, preferably for all ham bands? If anyone knows which company sells parts to build such a unit, it would be helpful. I'd also like to build a beam antenna for 20, 40, and 80 meters.

3978 **Roman H. Perkitny**
Cocoa, FL

Could someone give a short explanation of bi-directional parallel port theory using GW-BASIC? I would like to communicate in both directions with a project PC board plus a computer. Which parts? How do I control the direction of data flow, etc.?

3979 **Francis E. Orzechowski**
Lakeland, FL

I am looking for a circuit that will provide a decade prescaler for a frequency counter with input frequency up to 100 MHz. I also need one that will work up to 1,000 MHz.

39710 **Bob Dunn**
Modesto, CA

I do electronic repair for the company I work for. Boards come from overseas. I need a steady source for 8749HD microcontrollers, L702N ICs, L6203 ICs, IRFP450R FETs, and MC68B21P peripheral interface adapters. We have been promised some from Piconol of Belgium, but have not received them.

39711 **Terry C. Crowe**
Woodruff, SC

I need to build a tester for IR remote controls. Can someone help?

39712 **Antonio Loreto**
Venezuela, South America
E-Mail: oretol@ven.net

I am an art major working on small solar-powered sculptures. Does anyone know where to get micro motors the size of the ones you find in pagers or smaller, working on 1-9 volts, 10 MM bright clear blue LEDs of 350 MCD and up in brightness, and two-color 10 MM LEDs?

39713 **H. Saint James**
Mendocino, CA

In regards to an article written by Mark Emery Bolles in the Nov. '94 issue "An Easy-to-Build, Inexpensive Video Game"... I was wondering where to get the AY-3-8500-1 video game IC, since Jameco doesn't appear to have it any more. For a list of part supplier's addresses that may have such a beast, I would be very grateful.

39714 **Charles R. Oblender**
Milan, OH

Some, if not all, copy machines use a "folded" lens; the flat surface is a mirror. How is this lens used? I need a diagram.

39715 **Neil A. Benson**
Red Wing, MN

Where can I find special parts for a Heathkit weather station? I need reed switches and a meter movement for mine.

39716 **George Hoke**
Williams, AZ

I want to install a fluorescent light fixture in a commercial truck. Most of the off-the-shelf neon lights designed for 12 VDC do not put out enough light. At least nowhere close to a standard four foot household fixture.

Can someone help me find a place to get one, or describe the voltages and frequency required to convert or build the electronics?

I want quality, not a cheap circuit — build once and forget about it. There must be a source available (recreational vehicles, etc.). I just can't find it.

39717 **Dusan Benko**
Brooklyn, NY

I need a device that will answer an incoming phone call with a recorded message requesting the caller to enter a security code or wait for assistance. If the correct code is entered, extension A (telephone, etc.) will ring. If no code or an incorrect code is entered, extension B (fax, answering machine, etc.) will ring. Any assistance you can give will be appreciated.

39718 **Wesley S. Newswanger**
Ephrata, PA
martinmachinerymo@juno.com

Several years ago, I attended a crime prevention course at the University of Kentucky. I was particularly impressed with a homemade proximity card reader.

The instructor claimed that his 15-year-old son had actually built the proximity card reader out of inexpensive electronic parts purchased from a local Radio Shack store. The card reader consisted of a small PC board with a number of electrical wires, resistors, etc. and a small LED display window device that displayed the encoded numbers, etc. contained on various types of information cards — including some credit cards, library cards, etc. — when one of the course students held his respective card within 8 to 10 inches of the card reader.

If I had not seen it with my own eyes, I probably wouldn't believe that it was possible, but I did see it. I have spoken to a number of people involved in electronic kit building and design and many of them believe that such a card reader is possible to build using simple electronic parts purchased at a local Radio Shack store, etc.

I give seminars several times a year and would like to obtain kit plans, etc. for building this device for teaching purposes.

I am writing to you as a last resort,

ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of $25.00 will be paid within four weeks of publication if your answer is printed.
- Only one answer per question will be printed.
- If you do not want your name, address, or phone number available to the reader please so indicate or it will be assumed that you have no objection.
- In the event that more than one person submits the same solution, the choice will be made at the discretion of the publisher.
- Due to space limitations, we can not reprint the original questions with the answer. The question number and the issue it appeared in are printed above the answer.

QUESTION INFO
TO BE CONSIDERED FOR PUBLICATION

All questions should relate to one or more of the following:
1) Circuit Design 3) Problem Solving
2) Electronic Theory 4) Other Similar Topics

INFORMATION/RESTRICTIONS

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

HELPFUL HINTS

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address and Phone Number. Only your name will be published with the question, but we may need to contact you.

TECH FORUM

at the suggestion of my son who believes there is someone out there in the *Nuts & Volts* readership who will point me in the right direction.

39719 **Francis Coleman**
Washington, DC

I am trying to repair a stereo cassette player (Sharp RT-1165) which features an automatic program search system. This operation hinges on a voltage "draining" a 220 MFD cap about every two seconds by a Hall switch (a DN838 transistor) which is no longer available either from Sharp or anyone else on this planet. Shorting out this cap restores operation, but unfortunately, also prevents automatic shutoff. I can do without the search feature, but would desire the end-of-tape shutoff. Is there a substitute for the DN838, or can you suggest a change in the circuit to give me automatic shutoff?

39720 **M. B. Gembala**
Port Orange, FL

I need a circuit to be placed across a 12-volt car battery, that will energize a lead, to trip an alarm when, and only when, current is drawn from the battery.

39721 **R. H. McMinn**
Whittier, CA

In a projects book I picked up from the library, it calls for the use of an AD590 IC. The shops in this area can't cross-reference this number. Does anyone carry an AD590 IC temperature transducer or know where to find one?

39722 **Bill French**
Falls Church, VA

I have a natural gas furnace which uses a 1/3 HP capacitor, less than 12 amps, 115 volts, direct drive motor using a 20-amp circuit breaker.

I would like to operate the furnace off of a gasoline powered generator rated at 110 volts, 1000 watts, 60 cycle supply. I have tried this for a very short time, it will start and continue to run the furnace.

My worry is the possibility of causing harm to either the furnace motor or generator with continuous operation. If there is no cause for worry, how can I protect my generator and furnace?

39723 **Harry Loy**
Centerton, AR

A recurring problem with handheld games, remote controls, etc. is that the rubber membrane pad deteriorates over time, resulting in a loss of contact with the internal circuit board.

Continued on page 105

ANSWER TO #2972 - FEB. 1997

The HP 2686A comes from the factory with a serial port connector which is configured at factory for RS-232 at 9600 baud. However, optional Centronics ports were available. In most cases, you can assume that if you have a DB-25 connector on the unit, it is a serial port.

The type of serial port (RS-232 or RS-422) and the baud rate is changeable via jumper and DIP switches found inside the printer. To find these, you must remove the rear vented plastic panel which has four screws in it. This panel is on the upper half of the rear side of the laser printer. BEFORE REMOVING ANY PANELS OR CHANGING ANY DIP SWITCHES, MAKE SURE THE COMPUTER AND PRINTER ARE TURNED OFF AND UNPLUGGED!

After removing the rear panel, you will see a set of connectors just under the top cover of the printer, on the left-most side.

Between the two connectors, you will find a jumper with four pin pairs (labeled JP2). To configure for RS-232, which is standard for most computer systems, jumpers should bridge the pin pairs numbers one and three (the jumpers connect the pin pairs vertically) as such:

| : | : (| = jumper : = open pin pair)
1 2 3 4

If you wish, the printer set-up for an RS-422, the opposite pin pairs should be jumped (numbers 2 and 4) as such:

: | : |
1 2 3 4

You have now set the interface for either RS-232 (standard for most computers) or RS-422.

The next thing to do is to check the communications speed for the serial port. Look for an eight-switch DIP switch marked SW1. I don't have my printer open, but I think it is on the right side under the same panel you removed for the serial port jumpers.

The switches effecting baud speed are numbers 2, 3, and 4. Switch 1 should be the left-most in the DIP switch bank, and ON is "up."

Switch number			BAUD
2	3	4	
off	off	off	300
off	off	on	600
off	on	off	1200
off	on	on	2400
on	off	off	4800
on	off	on	9600 (factory default)
on	on	off	19200

Depending upon your computer and the speed of the UART in your serial port card, you should be able to use either 9600 or 19200 baud. You will want to make sure whatever speed you chose matches the speed your serial port and printer driver are set for (done at your computer).

Just in case someone messed around with the other DIP switches, here is what they do:

Switch 1: PORT TYPE
OFF: for serial port
ON: if your printer has the optional Centronics port and you want to use it

Switches 2, 3, 4 BAUD RATE, see above chart

Switch 5: (AUTOCONTINUE)
ON: continue on print and data errors after flashing 10 times
OFF: (DEFAULT) flash error until operator presses the continue key

Switch 6: ROBUST X-ON
ON: X-ONs repeated every one second when printer waiting for data
OFF: (DEFAULT) only one X-ON sent when printer needs more data

Switch 7: AUTO SELECT MODE (only functions on HP 2686D dual paper carrier version)
ON: powers up in auto-select mode
OFF: (DEFAULT) powers up with auto-select off

Switch 8: DTR POLARITY
ON: (DEFAULT) DTR pin 20 high when printer ready
OFF: DTR pin 20 low when printer ready

After setting the DIP switches correctly, replace the vented panel on the printer with the four screws.

Next, you need to make sure you have a proper cable to connect your computer's serial port to the printer.

This printer DOES NOT use a standard serial cable. Doing so may cause unwanted current to be transferred between the printer and requires a null modem cable. The following connections are needed to operate this printer from a standard serial port:

PRINTER (MALE CONNECTOR)	COMPUTER (FEMALE CONNECTOR)
PIN 1 (Chassis Ground)	PIN 1 (Chassis Ground)
PIN 3 (RD)	PIN 2 (TD)
PIN 2 (TD)	PIN 3 (RD)
PIN 7 (Sig. Gnd.)	PIN 7 (Sig. Gnd.)
PIN 20 (DTR)	PIN 5 (CTS) _AND_ PIN 6 (DSR)

If you are unsure whether your cable is providing the above connects, use an ohmmeter and check for continuity.

DO NOT connect any other pins between your computer and printer. HP used some pins for diagnostics and damage may result to either your computer or printer. This is particularly true if you are using a computer with non-standard serial ports, such as a Commodore Amiga. (I know ... I damaged both my computer and printer doing this!)

If you are still using an MS-DOS-based OS (rather than Windows), you should probably place the following lines in your autoexec.bat file:

Mode COM1:XXXX,N,8,1,P
(note: XXXX is replaced with baud speed printer is set for)

Mode LPT1:=COM1

Other notes about the HP 2686A printer:

The basic HP 2686A has only 128K memory in it. This is on the motherboard. I have been told by HP that there is no way to increase this memory (unfortunately). There was an upgrade at one point that replaced the whole motherboard and provided two megs of memory, but it is long gone, and costs over $4,000.00 new!

Some units might have had HP LaserJet 500 or HP LaserJet+ motherboards put in them. These have 512K memory.

The limited memory is a real limitation if you plan on doing any bit mapped, scalable, or graphic related printing. With 128K you can only print about one inch cross at 300 dpi. In order to print a full page, you must print in 100 dpi. With the 512K you can get about one-half page at 300 dpi.

The printer itself comes with two fonts built-in, courier portrait and landscape ... that's it. However, you can often find font cartridges around inexpensively. These same cartridges also fit the HP II (not IIP) printer. Any cartridge font can be printed in full resolution (300 dpi) on a full page. If you can find an HP Pro-collection or equivalent cartridge, this will provide you with about 60 fonts at once. Also, Windows has a driver for this cartridge.

Last comment: These printers are extremely well built, and can last for many, many years. They are eight-page-per-minute printers and good for continuous printing jobs where you are using a mail merge or something requiring many sheets to be printed. These days, the cartridges are now cheap and easy to come by, and can be refilled numerous time before needing to be rebuilt.

There are drivers available in Windows 3.11, but as far as I know, there are no drivers for Windows 95. In any event, the printer's usefulness for graphics and/or non-resident fonts is very limited due to the memory constraints and the fact that it is not expandable.

Larry Supremo
Baltimore, MD

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3465A, 4.5 Digit Multimeter $175
3466A, 4.5 Digit Multimeter $200
3468A, 5.5 Digit Multimeter $275
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355C, Step Attenuator, DC-1 GHz $275
3582A, Spectrum Analyzer, .02 Hz-25.5 KHz, Cal'd $2500
3764A/opt 1, Dig. Transmission Analyzer, HP Cal'd $7500
432A/478A, Power Meter, 10 MHz-10 GHz $300
4342A Q-Meter $2000
435A/8481A, Power Meter, ... $800
10 MHz - 18 GHz, -30 to +20 dBm
435A/8481H, Power Meter, ... $900
10 MHz - 18 GHz, -10 to +35 dBm
435A/8483A, Power Meter, 75 ohm $800
100 KHz - 2 GHz, -30 to +20 dBm
435A/8484A, Power Meter, ... $800
10 MHz - 18 GHz, -70 to -20 dBm
4437A, Step Attenuator, DC-1 GHz, 600 ohm $200
5006A, Signature Analyzer $450
5300A w/5302A, 50 MHz Counter $150
5300A w/5303A, 500 MHz Counter $300
5300A w/5303B, 525 MHz Counter $325
5300A w/ 5304A 10 MHz Timer/Counter $125
5300A w/5308A 75MHz Counter $175
5314A, 100 MHz Counter $200
5328, 100 MHz Counter $250
5383A, 500 MHz Counter $300
6024, Autoranging Pwr. Sup., 0-60V, 10A, 200W $750
6102A, Pwr. Sup., 0-40V@0.5A $150
6112A, Precision Pwr. Sup., 0-40V@0.5A $350
6114A, Precision Pwr. Sup., 0-20V@2A or 20-40V@1A . $550
6200B, Pwr. Sup., 0-40V@0.75A or 0-20V@1.5A $225
6201B, Pwr. Sup., 0-20V@1.5A $175
6202B, (Har), Pwr. Sup., 0-40V@0.75A $175
6214C, Pwr. Sup., 0-10V@1A $100
6253A, Dual Pwr. Sup., 0-20V@3A $500
6255A, Dual Pwr. Sup., 0-40V@1.5A $500
6384A, (Har), Pwr. Sup., 4-5.5V@8A $150
6448B, Pwr. Sup., 0-600V@1.5A $725
6824A, Pwr. Sup./Amplifier $350
+/- 50V, +/-1A, 20 dB gain, DC-10 KHz
7090A, Measurement Plotting Sys. $1700
738AR, Voltmeter Calibrator $250
7550A, 8-Pen Vector Plotter $1200
779D, Directional Coupler, 1.7-12.4 GHz $200
8007B, 100 MHz Pulse Generator $550
8011A, 20 MHz Pulse Generator $325
8082A, Pulse Gen., 250 MHz $1250
8406A, Comb Generator, 1/10/100 MHz to 5 GHz $400
8496B, 110 dB Step Attenuator, DC-18 GHz $650
86601A, RF Plug-In, .01-110 MHz $250
86602A, RF Plug-In, 1-1300 MHz $500
86631B, Aux Section (AM) $125
X382A, Var Atten, 0-50 dB, 8.2 GHz-12.4 GHz $125
X486A, Therm Mount, 8.2 GHz-12.4 GHz $175
X752D, Directional Coupler, 20 dB, 8.2-12.4 GHz $75
X885A, Phase Shifter, 8.2 GHz-12.4 GHz $275

TEKTRONIX

442, 35 MHz Dual Trace Oscilloscope $300
465, 100 MHz Dual Trace Oscilloscope $450
466, 100 MHz Dual Trace Storage Oscilloscope $600
475, 200 MHz Dual Trace Oscilloscope $650
576, Curve Tracer $2000
7104, 1 GHz O'Scope frame $2000
7104, 1 GHz O'Scope w/ (2) 7A29-04, 7B10, 7B15 ..... $3200
7613, 100 MHz Storage O'Scope w/ (2) 7A26, 7B53 ..... $600
7633, 100 MHz Storage O'Scope w/ (2) 7A26, 7B53 ..... $650
7704A, 200 MHz O'Scope w/ (2) 7A26, 7B70 ..... $750
7834, 400 MHz Storage Oscilloscope $1000
w/ 7A24, 7A26, 7B80, 7B85
7903, 500 MHz O'Scope w/ 7A24, 7A19, 7B92A $1100
7904, 500 MHz O'Scope w/ 7A24, 7A19, 7B92A $1100
7A13, 105 MHz Differential Comparitor $250
7A18, 75 MHz Dual Trace Amplifier $75
7A22, 1 MHz High CMRR Differential Amplifier $250
7A26, 200 MHz Dual Trace Amplifier $125
7B50A, 150 MHz Time Base $125
7B53A, 100 MHz Dual Time Base $125
7B70, 200 MHz Time Base $125
7B71, 200 MHz Delaying Time Base $150
7B80, 400 MHz Delaying Time Base $175
7B85, 400 MHz Delta Delaying Time Base $150
7B92A, 500 MHz Dual Time Base $250
7CT1N, Curve Tracer Plug-In $350
7D11, Digital Delay $100
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DC504 Counter, 100 MHz Timer/Counter $100
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FG504, 40MHz Function Generator $750
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PG502, 250 MHz Pulse Generator, TM500 series $600
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SG503, Leveled Sine Wave Generator $800
SG505, Ultra-Low Dist. Oscillator, 10 Hz-100 KHz $675
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TM506, 6-slot Power Module $175

MISCELLANEOUS

Ailtech 7512, Precision Noise Figure Indicator $750
Ailtech 7615, Noise Generator, 10MHz-1.5 GHz $225
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Data I/O 29B, Universal Programmer w/ manual $150
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SysDon 101, 10 MHz Pulse Generator $100
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Wavetek 154, Prog. Waveform Gen., .001Hz-10MHz $350
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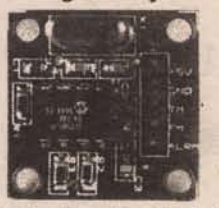

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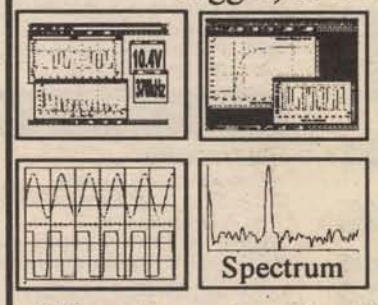

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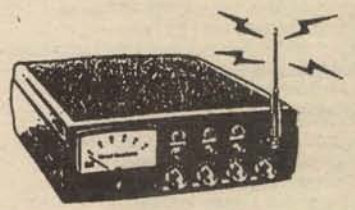

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Generator, dual channel option
TEK FG5010 Programmable 20 MHz $1,200.00
Function Generator, TM5000 series
WAVETEK 288 20 MHz Synthesized $1,500.00
Function Generator, GPIB

VOLTAGE & CURRENT

VOLTMETERS

HP 3456A 6-1/2 Digit Voltmeter $850.00
KEITHLEY 181 6-1/2 digit Nanovoltmeter, ... $1,500.00
10 nV sensitivity, GPIB
SOLARTRON 7081 8-1/2 digit Voltmeter $3,900.00
FLUKE 332B/AF DC Voltage Calibrator, ... $675.00
0-1111 V, 0-50 mA, 7 decades
FLUKE 343A DC Voltage Calibrator, ... $1,375.00
0-1100 V, 7 decades, 20 ppm acc.
FLUKE 510A AC Reference Standard, 10 VRMS, 0-10 mA $450.00
FLUKE 515A Portable Calibrator, ... $1,250.00
DC/AC/Ohms, line & battery power
FLUKE 5220A Transconductance Amplifier, DC-5 kHz, 0-20 A $3,750.00
FLUKE 720A Kelvin-Varley Voltage Divider, 7 decade $2,250.00
FLUKE 731B DC Reference Standard $400.00
FLUKE A55-series AC Thermal Converters $300.00
VALHALLA 2703 AC Volt.Std., ... $2,500.00
0-120V/10 Hz-100 kHz;120-1200V/10 Hz-1 kHz

VOLTAGE SOURCES

HP 6115A Precision Dual Range $875.00
Power Supply, 50V 0.8A / 100V 0.4A

CURRENT METERS & SOURCES

DRANETZ 656A /(3)TR2019A Current Demand $5,000.00
Analyzer, w/(3) current probes 300A max.
HP 4140B Picoammeter / DCV Source $4,000.00
HP 6177C DC Current Source, to 50V, 500mA $600.00
HP 6181C DC Current Source, to 100 V, 250 mA $675.00
HP 6186C DC Current Source, to 300V, 100mA $750.00
KEITHLEY 414A Picoammeter, 0.1 nA-10 mA $325.00
KEITHLEY 486 Picoammeter $1,500.00
KEITHLEY 614 Electrometer $1,000.00
KEITHLEY 642 Electrometer $2,900.00
TEK 7A14 Current Probe Amplifier, for P6021, P6022 ..... $125.00
TEK CT-5 -opt.05 High Current $500.00
Transformer for P6021/A6302, to 1000A
VALHALLA 2301 Programmable Single Phase Power Analyzer $1,250.00
VALHALLA 2575A AC/DC Active Current $1,000.00
Shunt, 20 mA-100 A, DC-10 kHz

IMPEDANCE & COMPONENT TEST

L.C.R.

BOONTON 62AD 1 MHz Inductance Meter, 2-2000 uH $550.00
HP 4261A 3-1/2 digit LCR Meter, 120 Hz/1 kHz $1,000.00
HP 4262A-101 4-1/2 digit LCR Meter, ... $2,200.00
120 Hz/1 kHz/10 kHz, HPIB
HP 4275A-001 5-1/2 digit LCR Meter, ... $6,000.00
10 kHz-10 MHz, 0-35 V int. bias
HP 4332A Analog LCR Meter, ... $600.00
3 uH-1 H/ 3 pF-1 uF/ 3 ohm-1 Megohm

STANDARDS

E.S.I. SR1010 Resistance Transfer $700.00
Standards, 1 ohm-100 K/step
E.S.I. SR1050-10M Resistance T $2,500.00
ransfer Standard, 10 Megohms/step
GR 1403-SERIES Standard Air Capacitors, 0.1% accuracy $150.00
GR 1406 Standard Air Capacitors, GR900 connector, 0.1% acc. $375.00
GR 1409-SERIES Standard Mica Capacitors, 0.05% accuracy $150.00
GR 1412-BC Decade Capacitor, 50 pF - 1.11115 uF $350.00
GR 1432-N 5-Decade Resistor, ... $175.00
to 11,111 ohms, 0.1 ohm res.
GR 1432-U 4-Decade Resistor, ... $125.00
0-111.10 ohms, 0.01 ohm resolution
GR 1433-J 4-Decade Resistor, ... $350.00
0-1,110 ohms, 1 ohm resolution
GR 1433-L 4-Decade Resistor, ... $350.00
0-11,110 ohms, 10 ohm resolution
GR 1433-N 5-Decade Resistor, ... $400.00
0-11,111 ohms, 0.1 ohm resolution
GR 1433-Q 4-Decade Resistor, ... $350.00
0-1,111,000 ohm, 100 ohm resolution
GR 1433-U 4-Decade Resistor, ... $350.00
0-111.0 ohms, 0.01 ohm resolution
GR 1433-W 6-Decade Resistor, ... $450.00
0-11,111.1 ohms, 0.01 ohm resolution
GR 1433-X 6-Decade Resistor, ... $450.00
to 111,111.0 ohms, 0.1 ohm res.
GR 1434-G 7-Decade Resistor, ... $300.00
0-1,111,111.0 ohms, 0.1 ohm res.
VALHALLA 2724A Programmable $1,675.00
Resistance Standard, 0-11 Gigaohms, GPIB

HI & LO RESISTANCE

HP 4329A High Resistance Meter, ... $1,350.00
5E5-2E16 Ohms, 10-1000 V test
VALHALLA 4150-ATC 4-1/2 digit $1,000.00
Ohmmeter, 20 milliohms-2 kilohms, 4-wire

CURVE TRACERS

TEK 577D1/177 Storage Curve Tracer, ... $2,250.00
with standard test fixture

T.D.R.

TEK 1503-opt.04 Time Domain Reflectometer, ... $1,600.00
0-50,000 feet,chart recorder

POWER SUPPLIES

SINGLE OUTPUT

HP 6200B Dual Range Power Supply, ... $250.00
20 V 1.5 A / 40 V 0.75 A CV/CC
HP 6201B 20 V at 1.5A CV/CC Power Supply $200.00
HP 6206B Dual Range 0-60 V 0.5 A / 0-30 V 1 A CV/CL Supply $250.00
HP 6207B 160 V at 200 mA CV/CC Power Supply $300.00
HP 6209B 320 V at 100 mA CV/CC Power Supply $300.00
HP 6260B-027 10V at 100A CV/CC Power Supply $675.00
HP 6261B-027 20 V at 50 A CV/CC Power Supply $675.00
HP 6263B 20 V at 10 A CV/CC Power Supply $400.00
HP 6266B 40 V at 5 A CV/CC Power Supply $400.00
HP 6268B-027 40 V at 30 A CV/CC Power Supply $850.00
HP 6299A 100 V at 750 mA CV/CC Power Supply $250.00
HP 6384A 4.0-5.5 V at 8 A CV/CL Power Supply $175.00
HP/HARRISON 6443B 120 V at 2.5 A CV/CC Power Supply $400.00
LAMBDA LES-EE-03-OV 36 V $500.00
at 14.5 A CV/CC Power Supply, LED metered
SORENSON DCR 110-45T 110 V at 45 A CV/CC Power Supply $2,200.00
SORENSON DCR 300-6B 300 V at 6 A CV/CC $950.00
Power Supply, 120 VAC 30 A line
SORENSON DCR 300-8A 300 V at 8 A CV/CC $950.00
Power Supply, 208/230 VAC line
SORENSON SRL 20-12 20 V at $550.00
12 A CV/CC Power Supply, low noise
SORENSON SRL 60-8 60 V at $950.00
8 A CV/CC Power Supply, low noise
TEK PS501-1 Power Supply, ... $175.00
0-20 V, 2 mV res., 400 mA, TM500 series

MULTIPLE OUTPUT

HP 6227B Dual 25 V at 2 A CV/CC Power Supply, tracking $550.00
HP 6253A Dual Output 20 V 3 A CV/CC Power Supply $500.00
HP 6255A Dual Output 40 V 1.5 A CV/CC Power Supply $500.00
TEK PS5010 Programmable Triple Power Supply, TM5000 series $800.00

MISCELLANEOUS

HP 59501A HPIB Isolated DAC/Power Supply Programmer $175.00
HP 6827A Bipolar Power Supply/Amplifier, to 100 V, 500 mA $800.00
KEPCO BOP 100-4M Bipolar Supply / $1,000.00
Amplifier, 0-100 V, 0-4 A
TRANSISTOR D DAL-50-15-100 Programmable $200.00
Load, 0-50 V, 0-15 A, 100 Watts max.

UNIVERSAL COUNTERS

UNIVERSAL COUNTERS

HP 5315A-001 100 MHz/100 nS $650.00
Universal Counter, TCXO reference
HP 5315A-001,003 100 MHz/100 nS $800.00
Universal Counter, TCXO, 1 GHz C-channel
HP 5316A 100 MHz/100 nS Universal Counter, HPIB $750.00
HP 5316A-003,006 100 MHz/100 nS Counter, ... $1,100.00
1 GHz C-ch., offset/normalize
HP 5334A 100 MHz Universal Counter, HPIB $875.00
HP 5334B-010,060 100 MHz Universal $1,000.00
Counter, HPIB, OCXO
HP 5335A 200 MHz Universal / Statistical Counter $1,500.00
HP E1420A-010,030 VXI card 200 MHz/ 2 nS $900.00
Univ. Counter,TCXO& 2.5 GHz C-ch
RACAL-DANA 1992-04,55 100 MHz/1 nS $850.00
Univ. Counter, 1.3 GHz C-channel,OCXO,GPIB
TEK DC5004 Programmable 100 MHz/100nS $350.00
Counter/Timer, TM5000 series
TEK DC5009 Programmable 135 MHz Univ. $600.00
Counter/Timer, TM5000 series
TEK DC503A 125 MHz Universal $450.00
Counter/Timer, TM500 series

FREQUENCY COUNTERS

EIP 575 18 GHz Source Locking Counter, GPIB $3,250.00
EIP 590-opt.92 WR19 Mixer Kit, ... $875.00
40-60 GHz, for EIP option 06 counters
FLUKE 7220A 1.3 GHz Communications Counter $550.00
HP 5340A-011 18 GHz Frequency Counter, HPIB $1,600.00
HP 5342A 18 GHz Frequency Counter $2,400.00
HP 5342A-003,011 18 GHz Freq.Counter, ... $2,750.00
+22 dBm,-20 dBm dynamic range,HPIB
HP 5342A-01,04,05,11 24 GHz Frequency $3,900.00
Counter, OCXO, DAC, and HPIB
HP 5345A/5355A/5356B 26.5 GHz $4,000.00
CW/Pulse Frequency Counter
HP 5382A 225 MHz Frequency Counter $200.00

STANDARDS

AUSTRON 1250A Crystal Frequency $600.00
Standard, 0.1/ 1.0/ 5.0 MHz
HP 105A Quartz Oscillator, 0.1/ 1.0/ 5.0 MHz $750.00

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AUDIO & BASEBAND

SPECTRUM ANALYZERS

HP 8556A LF Section, 20 Hz-300 kHz $450.00
TEK 7L5-opt.025/L3-1 Spectrum Analyzer, ... $2,250.00
20 Hz-5 MHz, 75 / 600 / 1M ohms

DISTORTION ANALYZERS

HP 334A Distortion Analyzer, ... $550.00
5 Hz-600 kHz, -60 dB, auto nulling
HP 339A Distortion Analyzer, built-in low distortion osc. $2,200.00

RMS VOLTMETERS

FLUKE 8920A True RMS Voltmeter, ... $700.00
180 uV-700 V, 10 Hz-20 MHz
FLUKE 8922A True RMS Voltmeter, ... $700.00
180 uV-700 V, 2 Hz-11 MHz

OSCILLATORS

HP 204C Oscillator, 5 Hz-1.2 MHz, 5 VRMS $150.00
HP 204D Oscillator, 5 Hz-1.2 MHz, ... $200.00
5 VRMS, 80 dB step attenuator
HP 209A Sine/Square Wave Generator, ... $225.00
4 Hz-2 MHz, 5 VRMS max.
HP 239A Low Distortion Oscillator, 10 Hz-100 kHz $450.00
HP 652A Test Oscillator, 10 Hz-10 MHz $300.00
TEK SG502 Sine/Square Osc., ... $200.00
5 Hz-500 kHz, 70 dB step atten.,TM500

MISCELLANEOUS

HP 3575A-001 Phase-Gain Meter, ... $900.00
1 Hz-13 MHz, dual display
HP 4437A Step Attenuator, ... $200.00
0-119.9 dB, DC-1 MHz, 600 ohms unbal.
KROHN-HITE 3103 High/Low Pass Filter, ... $500.00
10 Hz-3 MHz, 24 dB/octave
KROHN-HITE 3202 Dual High-Pass/Low-Pass $600.00
Filter, 20 Hz-2 MHz, 24 dB/oct
KROHN-HITE 3342 Dual HP/LP Filter, ... $1,100.00
0.001 Hz-99.9 kHz, 48 dB/octave
KROHN-HITE 3750 LP/HP/BP/BR Filter, ... $700.00
0.02 Hz-20 kHz, 6/12/18/24 dB/oct.
ROCKLAND 852 Dual $1,000.00
Highpass/Lowpass Filter, 0.1 Hz-111 kHz
TEK AM502 Differential Amplifier, 0.1 Hz-1 MHz, TM500 series $475.00

RF & MICROWAVE

SPECTRUM ANALYZERS

HP 11517A/18A/19A/20A Mixer, ... $675.00
12.4-40 GHz, w/adapters, for 8555A, 8565A, etc.
HP 11970A WR28 Harmonic Mixer, 26.5-40 GHz $1,100.00
HP 11970Q WR22 Harmonic Mixer, 33-50 GHz $1,400.00
HP 11970U WR19 Harmonic Mixer, 40-60 GHz $1,400.00
HP 11970V WR15 Harmonic Mixer, 50-75 GHz $1,600.00
HP 11971A WR28 Harmonic Mixer, 26.5-40.0 GHz, for 8569B $1,100.00
HP 11971K WR42 Harmonic Mixer, 18.0-26.5 GHz, for 8569B $1,100.00
HP 8406A Comb Generator, ... $450.00
1/10/100 MHz increments, to 5 GHz
HP 8444A-059 Tracking $1,500.00
Generator, 0.5-1500 MHz, for 8554,8568,etc.
HP 8445B Preselector, 1.8-18.0 GHz, for HP 8555A $650.00
HP 8557A/182T Spectrum Analyzer, ... $1,650.00
0.01-350 kHz, 1 kHz res., w/display
HP 8565A Spectrum Analyzer, ... $5,000.00
0.01-22 GHz, 1 kHz min. res. BW
HP 8569B Spectrum Analyzer, ... $9,000.00
0.01-22 GHz, 100 Hz min. res. BW
TEK 7L13/7633 Spectrum Analyzer, ... $2,250.00
1 kHz-1.8 GHz, 30 Hz min.res.,w/frame
TEK TR503 Tracking Generator, 0.1-1800 MHz, for 492/4/5/6 ..... $1,375.00

NETWORK ANALYZERS

HP 11589A Bias Network, 0.1-3.0 GHz, N(f/f) $350.00
HP 11590A-001 Bias Network, 1.0-18.0 GHz, APC7 ..... $450.00
HP 11665B Modulator, 0.15-18.0 GHz, for use with 8755/6/7 ..... $375.00
HP 11666A Reflectometer Bridge, 0.04-18 GHz, for 8755/8756 ..... $1,200.00
HP 85050D APC7 Calibration Kit, for 8510 series $1,100.00
HP 8505A-005/8503A Network An., ... $5,000.00
0.5-1300 MHz, w/S-Parameter & phase lock
HP 8755C/(3)11664A/182T Scalar Network $1,750.00
An. w/3 detectors, 10 MHz-18 GHz & frame
HP 8756A/(3)11664A Scalar Network Analyzer, ... $3,750.00
w/(3) detectors, 0.01-18 GHz
NARDA 7000A/7202/7206 Microwave Multimeter $1,950.00
System: scalar analysis 0.1-18 GHz
WAVETEK 1038D14A/H12/V13x2 Scalar $2,200.00
Network An,w/(3)15882 WR28 detectors,26.5-40 GHz

SIGNAL GENERATORS

FLUKE 6060A/AN Synthesized Signal Gen., ... $2,000.00
10 kHz-520 MHz, 10 Hz res,GPIB
GIGATRONICS 600/10-18 Synthesized Source, ... $2,600.00
10-18 GHz, 1 MHz res., GPIB
GIGATRONICS 605/10-18 Synthesized Source, ... $3,000.00
10-18 GHz, 1 kHz res., GPIB
GIGATRONICS 840-01 Freq. Doubler, ... $2,000.00
26.5-40 GHz (WR28) out, 13-20 GHz in
GIGATRONICS 875/50 Levelled Multiplier, ... $3,500.00
x4, 50.0-75.0 GHz output, -3 dBm
GIGATRONICS 875/86 Levelled Multiplier, ... $5,000.00
26.5-40.0 & 50.0-75.0 GHz outputs
GIGATRONICS 910/12-18,opt6,14,16 ..... $3,500.00
Synthesized Source/Sweeper, 12-18 GHz, 1 Hz res., OCXO
HP 85100V Frequency Mult., ... $4,250.00
10-15 GHz in / 50-75 GHz out >0 dBm
HP 8640B-001,002,003 Signal Gen., ... $2,500.00
0.5-1024 MHz, AM, FM, var. audio osc.
HP 8654A Signal Generator, ... $550.00
10-520 MHz, calibrated AM & uncal. FM
HP 8656A Signal Generator, 0.1-990 MHz, ... $2,900.00
100 Hz res, AM, FM, HPIB
HP 8660C/86602B/86632A Synthesized $2,750.00
Signal Gen., 1-1300 MHz, 1 Hz res., AM, FM
HP 8660D/86603A/86632B Synthesized $7,000.00
Signal Generator, 1-2600 MHz
HP 8671A-005 Synthesized CW Generator, ... $6,000.00
2.0-6.2 GHz, 1 kHz res., HPIB

SWEEP GENERATORS

HP 11869A Plug-in Adapter $450.00
HP 8600A Digital Marker, for HP 8601A $400.00
HP 8601A Generator/Sweeper, ... $400.00
0.1-110 MHz, +20 dBm levelled
HP 8620C Sweep Oscillator Frame $550.00
HP 8620C-011 Sweep Oscillator Frame, HPIB programmable $675.00
HP 86230B RF Plug-in, 1.8-4.2 GHz, +10 dBm unlevelled $675.00
HP 86240A RF Plug-in, 2.0-8.4 GHz, +16 dBm levelled $1,000.00
HP 86240A-002 RF Plug-in, ... $1,200.00
2.0-8.4 GHz, +14 dBm lvld., 70 dB step att.
HP 86241A-001 RF Plug-in, 3.2-6.5 GHz, +8 dBm levelled $500.00
HP 86242D-004,008 RF Plug-In, ... $500.00
5.9-9.0 GHz, +10 dBm levelled
HP 86245A RF Plug-in, 5.9-12.4 GHz, +16 dBm levelled $1,100.00
HP 86250D RF Plug-in, 8.0-12.4 GHz, +10 dBm levelled $675.00
HP 86260A RF Plug-in, 12.0-18.0 GHz, +10 dBm unlevelled $800.00
HP 86260A-H04 RF Plug-in, ... $800.00
10.0-15.0 GHz, +10 dBm unlevelled
HP 86290A RF Plug-in, 2.0-18.0 GHz, +7 dBm levelled $1,750.00
HP 86290B RF Plug-in, 2.0-18.6 GHz, +10 dBm levelled $2,250.00
HP 86290C RF Plug-in, 2.0-18.6 GHz, +13 dBm levelled $2,500.00
WAVETEK 962 Sweep Generator, ... $2,000.00
1.0-4.0 GHz, markers, +12 dBm unlvld.

POWER METERS

ANRITSU MP-81B/ML-83A Power Meter, ... $2,500.00
75-110 GHz (WR10), -20 to +20 dBm
ANRITSU MP-82B/ML-83A Power Meter, ... $3,250.00
90-140 GHz (WR8), -20 to +20 dBm
BOONTON 42B/41-4B Analog $375.00
Power Meter, with 1 MHz-12 GHz sensor
BOONTON 42B/41-4E Analog Power $500.00
Meter, with 1 MHz-18 GHz sensor
GENERAL MICR 476/4240A Power $375.00
Meter & Sensor, 0.01-18 GHz, -35 to +10 dBm
HP 432A/478A Power Meter, ... $375.00
10 MHz-10 GHz, -20 to +10 dBm f.s.
HP 432A/8478B Power Meter, ... $500.00
10 MHz-18 GHz, -20 to +10 dBm f.s.
HP 432C Autoranging Digital Power Meter, 10 uW-10 mW f.s. $425.00
HP 435A/8481A Power Meter, ... $1,000.00
10 MHz-18 GHz, -30 to +20 dBm
HP 435A/8482A Power Meter, ... $1,000.00
100 kHz-4.2 GHz, -30 to +20 dBm
HP 435A/8482H Power Meter, ... $1,150.00
0.1-4200 MHz, -15 to +34 dBm
HP K486A WR42 Thermistor Mount, ... $350.00
18.0-26.5 GHz, for 432 series
HP Q8486A Power Sensor, ... $1,500.00
33.0-50.0 GHz, WR22, for 435/6/7/8
HP R486A WR28 Thermistor Mount, ... $350.00
26.5-40.0 GHz, for 432 series

RF MILLIVOLTMETERS

RACAL 9303 TRMS Level Meter, ... $875.00
10 kHz-2 GHz, -77 to +23 dBm, GPIB

AMPLIFIERS, MISCELLANEOUS

BOONTON 82AD FM/AM Modulation Meter, 10-1200 MHz $800.00
HP 8447A-001 Dual Amplifier, 0.1-400 MHz $450.00
HP 8901A-002,010 Modulation Analyzer, ... $5,500.00
150 kHz-1300 MHz, OCXO, int. cal.
HP 8901B-001 Modulation Analyzer, ... $8,500.00
150 kHz-1300 MHz, rear panel input
HUGHES 1177H01F000 TWT Amplifier, ... $1,750.00
20 Watts output, 1.4-2.4 GHz
M.P.D. LAB2-1020-2A Amplifier, 34 dB, 1.0-2.0 GHz, 2 Watts $800.00
M.P.D. LAB2-714-3A Amplifier, 34 dB, 0.7-1.4 GHz, 3 Watts $800.00
MARCONI TF2304 AM/FM Modulation $500.00
Meter, 18-1000 MHz, FM dev.1.5-150 kHz
MICROWAVE SE MC5112 Noise Source, ... $325.00
25.5 dB ENR, 1.0-12.4 GHz, N(m), +28 VDC

COAXIAL & WAVEGUIDE

AMERICAN NUC AM-432 Cavity $95.00
Backed Spiral Antenna,LHC, 2-18 GHz,TNC(f) *NEW*
CONTINENTAL PLPT42 WR42 Low Power $125.00
Termination, 18-26.5 GHz, 1 Watt
FXR/MICROLAB S3-02N Triple Stub $90.00
Tuner, 200-1000 MHz, 100 Watts max., N(m/f)
GR 874-LTL Constant Impedance $450.00
Trombone Line, 0-44 cm, DC-2 GHz
GR 900-Q GR900 14mm Interseries Adapters $125.00
HP 11691D Directional Coupler, 22 dB, 2-18 GHz $450.00
HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz $800.00
HP 33330B Crystal Detector, ... $135.00
0.01-18 GHz, neg. pol., SMA(m)/SMC(f)
HP 774D Dual Directional Coupler, 20 dB, 200-500 MHz $275.00
HP 777D Dual Directional Coupler, 20 dB, 1.9-4.1 GHz $275.00
HP 8470B-012 Crystal Detector, 10 MHz-18 GHz, neg. pol., N(m) $250.00
HP K422A WR42 Flat Broadband Detector, 18.0-26.5 GHz $350.00
HP K532A WR42 Frequency Meter, 18.0-26.5 GHz $500.00
HP K752 A/C/D WR42 ..... $450.00
Directional Couplers, 3/10/20 dB, 18.0-26.5 GHz
HP K870A WR42 Slide Screw Tuner, 18.0-26.5 GHz $275.00
HP K914B WR42 Moving Load, 18.0-26.5 GHz $425.00
HP Q752D WR22 Directional Coupler, 20 dB, 33-50 GHz $650.00
HP R375A WR28 Variable Attenuator, 0-20 dB, 26.5-40 GHz $375.00
HP R422A WR28 Flat Broadband Detector, 26.5-40 GHz $400.00
HP R532A WR28 Frequency Meter, 26.5-40.0 GHz $500.00
HP R914B WR28 Moving Load, 26.5-40 GHz $300.00
HP X913A WR90 High Power Load, 500 Watts, 8.2-12.4 GHz $150.00
HUGHES 45111H-2000 WR28 Isolator, 25 dB, 26.5-40 GHz $450.00
HUGHES 45113H-1000 WR19 Isolator, 25 dB, 40-60 GHz $650.00
HUGHES 45514H-1001 WR15 Stepper $1,675.00
Motor Driven 4-Port Switch, with driver
HUGHES 45521H-2000 WR28 Manual 4-Position Switch $750.00
HUGHES 45713H-1000 WR19 Frequency Meter, 40-60 GHz $900.00
HUGHES 47316H-1111 WR10 Tuneable $750.00
Detector, 75-110 GHz, positive polarity
HUGHES 47323H-1211 WR19 Flat Broadband $650.00
Detector, negative, 40-60 GHz
HUGHES 47974H-1000 WR15 SPST PIN $375.00
Switch, 250 MHz speed, 60-62 GHz response
KAY 442D Step Attenuator, 0-101 dB, 75 ohms, BNC $100.00
KRYTAR 1818 Directional Coupler, 16 dB, 2-18 GHz, SMA(f) $200.00
M/A-COM 3-19-300/10 WR19 ..... $450.00
Directional Coupler, 10 dB, 40-60 GHz
MINI-CIRCUIT ZFDC-20-4 Directional $25.00
Coupler, 19.5 dB, 1-1000 MHz, SMA(f)
NARDA 25171 Level Set Attenuator, 0-17 dB, 2-8 GHz, SMA(f) $100.00
NARDA 26298 20 dB Attenuator, 150 Watts, DC-1 GHz, N(f/f) $200.00
NARDA 3000-SERIES Directional Couplers $150.00
NARDA 3024 Bi-Directional Coupler, 20 dB, 4-8 GHz $300.00
NARDA 3090-SERIES Precision High Directivity Couplers $225.00
NARDA 368NM Coaxial High $400.00
Power Load, 500 Watts, 2.0-12.4 GHz, N(m)
NARDA 369BNF High Power Termination, ... $325.00
175 Watts, 0.7-18 GHz, N(f)
NARDA 3753B Coaxial Phase Shifter, ... $1,250.00
0-60 deg./GHz, 3.5-12.4 GHz
NARDA 4000-SERIES SMA Miniature Directional Couplers $75.00
NARDA 4203-6 Directional Coupler, ... $225.00
6 dB, 2-18 GHz, SMA(f/f/f)
NARDA 4246B-20 Directional Coupler, 20 dB, 6-18 GHz, SMA(f) $100.00
NARDA 4317-2 Power Divider, 18.0-26.5 GHz, 3.5mm $175.00
NARDA 4799 Level Set Attenuator, 0-15 dB, 4-18 GHz, SMA(f) $135.00
NARDA 5070-SERIES Precision Reflectometer Couplers $300.00
NARDA 765-20 20 dB Attenuator, 50 Watts, DC-5 GHz, N(m/f) $135.00
NARDA 766-10 10 dB Attenuator, 20 Watts, DC-4 GHz, N(m/f) $100.00
NARDA 768-20 20 dB Attenuator, 20 Watts, DC-11 GHz, N(m/f) $125.00
NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz $375.00
PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz $250.00
SIERRA 662A-20 20 dB Attenuator, 100 Watts, N(f/f) $150.00
SONOMA SCIEN 21A3 WR42 Circulator, 20 dB, 20.6-24.8 GHz $125.00
SPACEK LABS DQ-1 WR22 Flat $550.00
Broadband Detector, 33-50 GHz
TELONIC TTF-2250-5-5EE Tunable $350.00
Bandpass Filter, 1.5-3.0 GHz, 5% 3 dB BW, N(f)
TRG V510 WR15 Precision Rotary $1,000.00
Vane Atten., 0-50 dB, 50-75 GHz
TRG V551 WR15 Frequency Meter, 50-75 GHz $600.00
TRG V559-10 WR15 Directional Coupler, 10 dB, 50-75 GHz $400.00
TRG W510 WR10 Precision $1,000.00
Rotary Vane Atten., 0-50 dB, 75-110 GHz
TRG W559-10 WR10 Directional Coupler, 10 dB, 75-110 GHz $475.00
WAVELINE 822 WR42 Precision Rotary $1,250.00
Vane Atten., 0-50 dB, 18-26.5 GHz
WAVELINE 898-DR WR42 Frequency Meter, 18.0-26.5 GHz $350.00
WEINSCHEL 1515 Power Divider, 2-Way, ... $125.00
DC-18 GHz, SMA(m/f/f)
WILTRON 26N50 Precision Termination, N(m), DC-18 GHz $250.00
WILTRON 60N50-opt.1 SWR Bridge, ... $500.00
5-2000 MHz, 46 dB directivity, N(m/f/f)
WILTRON 87A50 VSWR Bridge, ... $600.00
2-18 GHz, 35 dB dir., APC7 test port
WILTRON SP2369 SWR Autotester, 2-12 GHz, APC7 test port $400.00

LOGIC

FLUKE 9000A-series Microprocessor $375.00
Pods: 6800; 6809; 8080; 8085; Z80
HP 5005A Signature Multimeter $350.00
HP 8170A-002 Logic Pattern Generator, ... $1,200.00
2 MB/s, address driver option
TEK 1240 Logic Analyzer, w/(36) 50 MHz channels $1,500.00

COMMUNICATIONS

HP 59401A HPIB Bus Analyzer $700.00
TEK 1411R-opt.04 PAL Test Gen. $2,750.00
w/SPG12,TSG11,TSP11,TSG13,TSG15,TSG16
TEK 147A NTSC Test Signal Generator, with noise test signal $800.00
TEK 1750 NTSC Waveform / Vector Monitor $2,750.00
TEK 520A NTSC Vectorscope $1,200.00

MISCELLANEOUS

P.A.R. 5205-94,95,96,98 Lock-In Amp, ... $2,750.00
20 Hz-20 kHz, int. osc., lin/log, GPIB
P.A.R. 5206 Two-Phase Lock-In Amplifier, 2 Hz-200 kHz $2,500.00
P.A.R. 5208-92,94,97,98 Two Phase $3,250.00
Lock-In Amp., 5 Hz-20 kHz or 200 kHz, GPIB
TEK TM5006 5000-series 6-slot Programmable Power Module $600.00
TEK TM503 500-series 3-slot Power Module $175.00
TEK TM504 500-series 4-slot Power Module $175.00
TEK TM506 500-series 6-slot Power Module $250.00
TEK TM515 500-series 5-slot Traveller Power Module $275.00

The BENDER-2pp Tube Push-Pull Amplifier Rebuild Project

PART 2

by Steve Bender

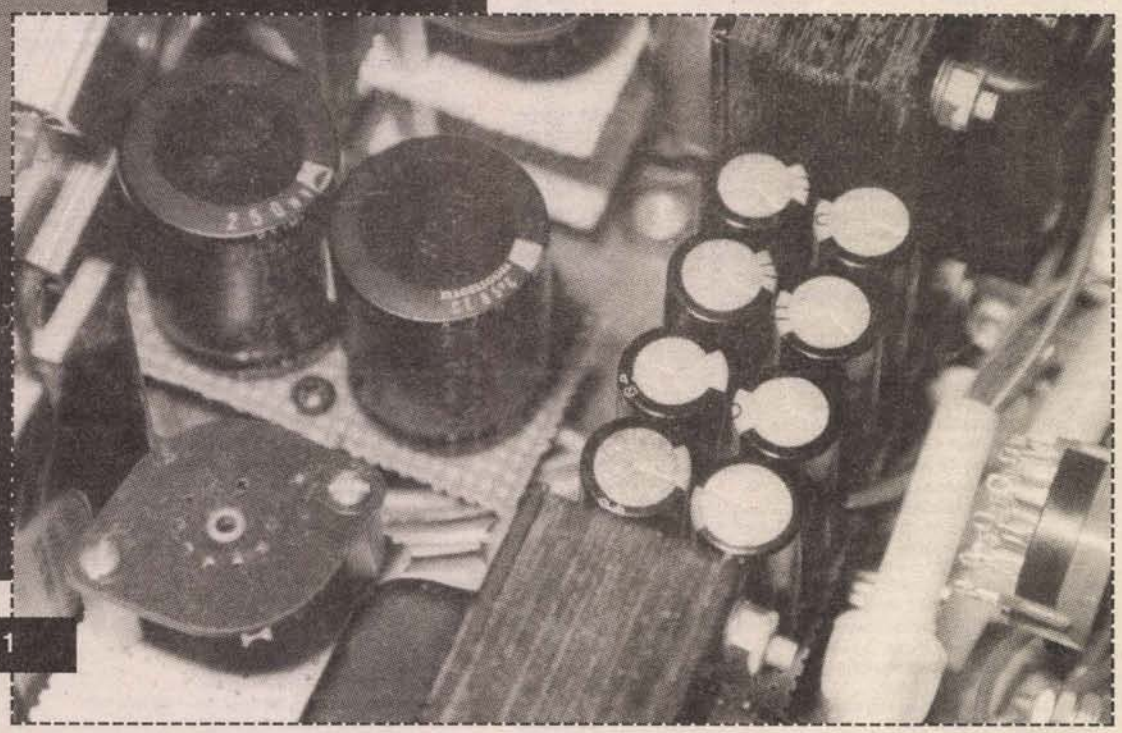

Photo 1

Last month, I explained the concept of rebuilding a 1960's transistor power amplifier using advanced tube technology. This project uses point-to-point wiring and perfboard/spacer technology, along with an SPS regulated power supply for the filaments, and a massive CAP Bank on the high-voltage line. Estimated time to complete the project is around 40 hours to 50 hours, as a lot of mechanical work is required. Wherever possible, existing holes can be used.

Since Part 1, the unit has undergone several major revisions. While I would have liked to have built and tested three or four prototype units — one using 5CZ5s, another using 10BQ5s, a third prototype using the Hammond transformers, etc. — time limitations and editorial deadlines had priority, so choices had to be made. The single prototype constructed is slightly unusual, in that the left channel is made using 5CZ5s, while the right channel uses 10BQ5s.

If you could see this, you'd notice that the 10BQ5s are somewhat taller and stick out above the chassis almost an additional half-inch. Also, the internal photo would show a pair of four-pin plug connectors on the right channel. These were designed in to allow an alternative output transformer, by simply plugging it in. But time constraints did not allow a rebuild and tests using the Hammond 1620s at this time. That will have to wait for another installment ...

As for the major revisions ... The first major revision was prompted by feedback from several audiophiles. Another project — a single ended paralleled triode amplifier (similarly built in a Dynaco Stereo-120 chassis) was displayed and auditioned back in Dec. '96 at a meeting of the Piedmont Audio Society in Apex, NC. That amp — like the project described here — used two fans to cool the system tubes and the switching power supply.

The attending audiophiles at Piedmont, again and again, berated the unit's fan noise. The second problem noted with fans, was the dust they inevitably suck in, which accumulates. This can lead to arcing, and related failure modes.

Last week, the fan in my desktop PC failed, and caused untold problems. That cinched it. Out with the fans — learn to live with the heat!

The ensuing rebuild of this amp and the S.E. triode unit, were altered to eliminate the fans. Back in Part 1, you may remember this project originally contained three fans. The BENDER-2pp was redesigned, rebuilding it around high-quality ceramic tube sockets that were designed for the Russian military — the types that need to be reliable inside a MIG-27 under heavy vibration and enclosed conditions.

One thing about these sockets: at first, the tubes seem almost impossible to push in. That is, the first time, so be careful. Interestingly, the Russian tubes (at least SOVTEK ones) have much more of a pinpoint end, as well as a tapered pin, compared to standard straight pins on the NOS American tubes. As a result, Russian tubes fit into these sockets more readily.

When using old NOS American tubes (as we are likely to be doing), some care needs to be taken in putting the tubes in. Once they are properly in, frankly, they are almost impossible to pull out ... but this makes for a reliable connection, and that is important.

The current unit produces prodigious amounts of heat around the output tubes and the center heatsink/shield. The cylinder surface at the center of the plate is the hot point on 5CZ5s and temperatures here were measured to reach 160° Celsius. After several hours of operation, the power transformer was found to have reached 39.5° Celsius on its external surfaces.

While this is above room temperature, it is not unusually hot, as most transformers are rated for continuous operation at 105° Celsius. Actually, after several hours, the power transformer may have been the coolest part inside the amplifier. The heatsink/shield was almost 50° Celsius, as the attached power resistors get quite warm.

The switching power supply (SPS) heatsink was hot, but this prototype unit is unusual and not typical. Using that single SPS, it's running just beyond its 5-volt ouput limit and about half on the 12-volt line for the differing channel's filaments. The design should prove to have no problems, and is believed to be reliable even without its fans, but this will be tested more as we work toward completion in Part 3.

Choosing Tube Sets

In reviewing the filament needs of the various output tubes which I selected as possible candidates, the 5CZ5 pentode has a 12-watt rated maximum plate dissipation, and its filament is rated at 4.7 volts/600 mA. While this tube is readily available for at least the near term (priced around $5-$8 apiece), two possible alternates (but not pin for pin substitutes) are: the 10BQ5 and the 10CW5 (both use 10.6 volt filaments). These draw 10.6 volts at 450 mA each.

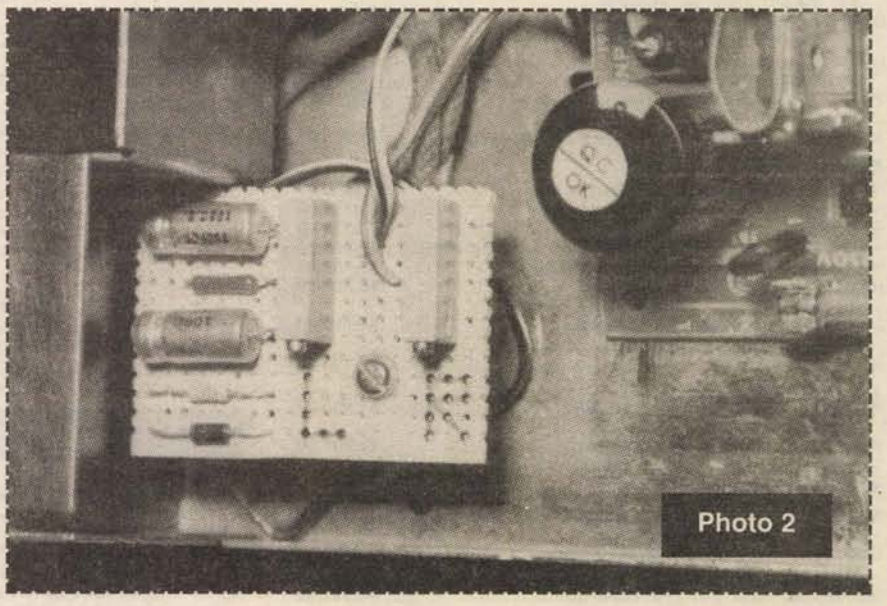

Photo 2

Bias levels tend to be different among these three

Chart 1 5CZ5 Bias Voltage vs. Plate I/V and Dissipation

VBias	V Rk	Plate Current	Plate V	Plate Dissipation
10.6V	3.75	175 mA	269.0V	46.4 watts*
16.5V	3.41	159 mA	273.4V	42.9 watts
20.1V	3.20	149 mA	278.2V	41.0 watts
23.0V	3.01	140 mA	280.5V	38.8 watts
27.0V	2.79	130 mA	281.0V	36.1 watts
30.0V	2.63	122 mA	281.4V	34.0 watts
32.5V	2.39	111 mA	282.1V	31.0 watts

* Plates started to show an orange/red stripe at this point.

Chart 2 10BQ5 Bias Voltage vs. Plate I/V and Dissipation

VBias	V Rk	Plate Current	Plate V	Plate Dissipation
-5.1V	3.33	154 mA	270.0V	41.0 watts
-8.0V	3.00	140 mA	273.0V	37.8 watts
12.0V	2.54	118 mA	275.0V	32.2 watts
16.0V	2.09	97.2 mA	287.5V	27.7 watts
20.0V	1.69	78.6 mA	288.0V	22.5 watts
25.0V	1.23	57.0 mA	291.5V	16.5 watts
29.0V	0.90	42.0 mA	292.3V	12.2 watts
32.0V	0.70	32.0 mA	293.2V	9.4 watts

tubes, so the tube set variables are: the voltages and current levels; the bias levels; and finally, the pin connections.

In an all 5GH8/5CZ5 (4.7-volt) system, a single 5-volt/5-amp SPS supply would suffice; in a 4.7/10.6-volt setup, it is quite probable that most multiple 5-volt/12-volt output SPS units (like Phihong's PSA-25-301) could be used, but the stacking of two supplies might be needed to avoid overload.

For input tubes, the 5AN8, 5GH8A, 5EA8, and 5U8 are similar pentode/triode candidates, and it was difficult choosing among them. The circuit and voltages used herein could accommodate any of these tubes. Again, the pin assignments are different, but not radically so. Sometimes the last three are considered to be interchangeable. I know that the six-volt 6AN8 sister tubes were used in some early Dynaco amplifiers, and the 6GH8A was similarly used in some amps from H.H. Scott. I chose the 5GH8A because I know that the six-volt version was used in at least one commercial circuit using the 6BQ5/7189s, which are brethren to the 10BQ5s mentioned above.

A 5GH8A/5CZ5 system would require 4.7 volts @ 1.8 amps per channel, or 4.7 volts @ 3.6 amps for both channels. A 5GH8A/10BQ5 system would require 4.7 volts @ 0.6 amp, and 10.6 volts @ 0.9 amp for each channel, or 4.7 volts @ 1.2 amps, and 10.6 volts @ 1.8 amps for a stereo pair. The 12-volt line voltage could be dropped using a negative temperature coefficient thermistor and one or two 1N4006 diodes in series with each tube heater. Variations of ±5% are perfectly acceptable.

The other noted possible alternative output tube – the 10CW5 — has a lesser maximum plate voltage rating, which isn't a problem in this circuit. Getting vastly different, 8BQ5s can probably be adapted to this design, if the SPS used can provide its filament voltage and current. But, again, such a substitution is only a possible option.

If chosen, it is left to the builder to make it work; configurations using the 10CW5 and 8BQ5 were not actually tested in this case. Some SPS ratings are given later, and there are several acceptable choices in SPS power supplies which were specified in Part 1.

Photo 1 shows the primary power supply with the CAP Bank behind it. I strongly suggest not omitting the primary cap's 300K bleeder resistors, which dissipates, at worst, about one watt. The CAP Bank provides the energy reserve used by the output stage, and the static current through the output transformers. The effective tube plate voltage is the B+ line (290-310 volts) minus the drop across the small cathode resistor (~.5 volts), so the resulting plate voltage is close to 300 volts. Good grounding techniques, using heavy gauge wire, is strongly recommended. I fashioned the main ground from three paralleled lengths of braid wire, making a 48 amp "cable" going from the CAP Bank central ground point to the front center of the chassis.

Details on the Design of the High-Voltage Supply

Continuing with specifics on the high-voltage power supply ... Since the high-voltage circuitry does not contain large power supply chokes due to physical constraints, the primary means of reducing ripple is a PI network consisting of R-C filtering. That is, a capacitor, series resistor, and another capacitor. The way this unit is wired, the CAP Bank caps are split with two series resistors, each going to a separate CAP Bank for each channel. The primary voltage doubler and input caps feed a pair of resistors and filter caps, each feeding one channel of the amplifier. The power resistors that go between the primary input caps and the CAP Bank are critical, as it determines the plate voltage for the output section.

Too high a value and the amp loses maximum output power due to a reduced plate voltage. On the other hand, too low a resistor value and residual AC hum will start to appear in the speaker. This resistor value is, of course, inversely proportional to the plate current; the more plate current, the lower the plate voltage.

I tried several values for this power resistor between 50 ohms and 300 ohms. Tests using 50-ohm/4-watt resistors (two 100-ohm/2-watt units in parallel), gave a plate voltage of around 269-270 volts, with the bias set to 100 mA in the output stage of each channel. This would be the maximum power configuration. Hum was audible at a low level in the speaker, and more so using headphones, so use of the 50-ohm value isn't recommended.

The original configuration, in the opposite extreme, was tested using 300-ohm resistors which dissipated over five watts per resistor. Using 10-watt resistors, they became quite hot, and this configuration had these mounted under the CAP Bank, flush with the chassis, dissipating part of their heat onto the steel chassis. The upward dissipated heat could adversely affect the CAP Bank over time, so I changed from that configuration.

The 300-ohm value reduced the hum to quite inaudible levels, but the plate voltage was very reduced, down from about 280 volts to 235 volts, clearly reducing the amplifier's output power. As a result of these tests, I don't recommend values below 150 ohms, as the hum can become audible. I do suggest choosing 150 ohms as a good compromise, in that it provides a plate voltage of around 275 volts, and each resistor dissipates under five watts.

I used a value of 150 ohms in the prototype, and hum level was just barely perceptible with my ear in contact with the woofer's cone, so I'm sure it could be measured. I mounted the pair of 15-watt chassis mounted resistors on the "tube" side of the heatsink, near the primary filter caps. The resistors I used had mounting holes good only for 2-56 screws, which I didn't have. It was possible to re-drill the holes using a Dremel Tool and a 1/8" drill, allowing 4-40 screw mounting.

There is a 2" x 3" area on the transformer side of the heatsink where such resistors could also be installed, but the wires reaching them would have to be longer. Use of 15-watt resistors here is mandated; they get quite warm, and need to be secured either to the heatsink or to the chassis behind the output stage, as either location is acceptable.

The design described here uses a pentode-in-pentode mode. Triode mode is a possibility, if you don't mind the power loss, which would be about 40%. This would mean omitting the existing screen grid resistors and tying the screen grid to the plate through a small resistor, from 10 ohms to 150 ohms. Triodes are known for their excellent sound capabilities and this could be an option; the improvement would most likely be audible. Beyond that, the amp could be designed for maximum power output or, for the best sound, while still running within its rated maximum power dissipation point.

Using four output tubes for each channel is another possible option, but introduces more load on the filament supply, physical space limitations, and the problem of additional heat. I opted for the more conservative topology, using one pair of output tubes per channel. The biasing circuit uses both a minus supply for bias, and a small cathode resistor (which allows you to easily make readings). Given that both the 5CZ5 and the 10BQ5 have 12-watt maximum rated plate dissipation, tube bias is determined by the (G1) grid voltage with respect to the cathode. A nominal level of 22 mA per tube (45 mA) is a good place to start. This circuit has a maximum total current of around 100 mA per channel as it approaches clipping.

The addition of an unbypassed, 22-ohm common cathode resistor allows a convenient place for circuit measurement (and there is also two ohms contributed by the 500 mA B+ line fuse and fuse holder). The 24 ohms in this circuit path was well worth the small additional losses. The unbypassed 22-ohm common cathode resistor is an excellent in-phase feedback source, adding to the circuit linearity. Granted that this is not, strictly speaking, a typical configuration, but I felt it necessary to increase stability, provide an intolerance to ground loops, and to improve the overall sound.

Details on the Bias Supply

The Dynaco transformer's 70-volt secondary is used with a 2000-ohm series resistor, a single diode wired for minus voltage, and a small pi series network

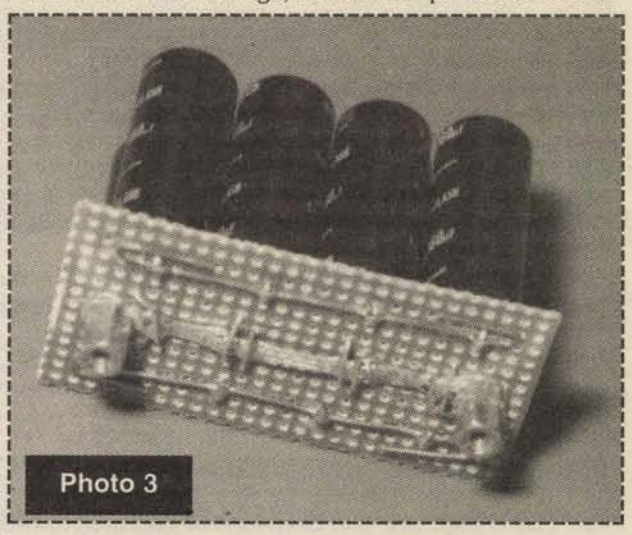

Photo 3

of a 10 uF/100-volt capacitor, an 82K ohm series resistor, and a second 10 uF/100-volt capacitor. The capacitor values could be increased to 100 uF, or any value in between. Just make sure you use 100-volt caps. This network is followed by a small 50K ohm trimpot used to adjust the bias level in each channel. These parts are mounted on a small perfboard near the SPS. Almost zero current is required from this supply, so parts values are not overly critical.

Originally, a 220K ohm resistor leading up to the center of the balance pot reduced bias voltage even further. For the 50K trimpot, I used a 20-turn, 3/4-

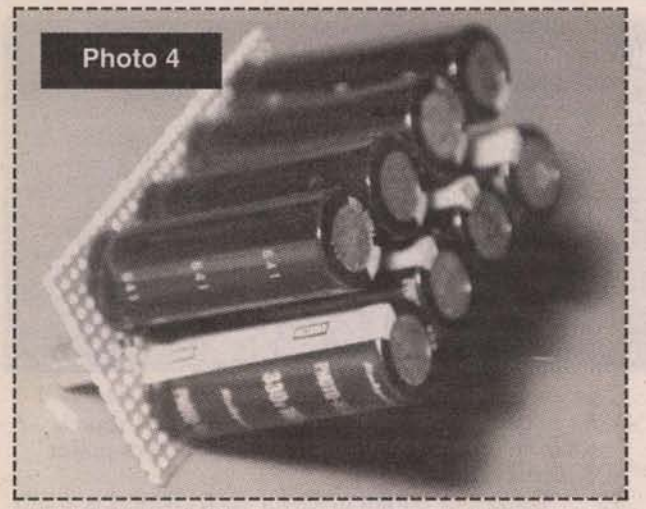
Photo 4

watt Bourns unit. These are screwdriver adjust trimpots, which allow precise adjustments to be made.

The revised bias circuit uses a resistive voltage divider (39K plus the 50K trimpot and its 10K resistor to ground) in series with the output. This drops the resulting -99 volts down to the desired bias levels (about -32.5 volts maximum). Setting the pot half way should produce around -18 volts. More on the bias levels and circuitry later.

After allowing the unit to stabilize for half an hour with no signal into the amplifier, measure the voltage across Rk — the top of the 22-ohm resistor in each channel. Dividing that voltage by 22 (ignoring the ~2 ohms contributed by the B+ line fuse and wire), one obtains a value pretty close to the actual quiescent current flow for both tubes. An Rk voltage that gives between 45 and 140 mA current flow in that circuit should be appropriate, depending on the tubes. Quiescent current values between 45 mA (about 1.00V across Rk) and 140 mA (3.00V across Rk) are permissible values given a nominal 280 volts on the plates. The Rk value represents the current flow for both tubes, and a nominal 45 mA. quiescent current (1.000V across Rk) should be the desired median level.

The AC balance circuit consists of another small single turn potentiometer and resistors wired into the grid circuit after the phase splitter. Using matched output tubes certainly helps, but the AC balance adjustment can be used to improve performance. There is some interaction between the balance control and the bias level, so adjusting the AC balance significantly, may mean slightly re-adjusting the bias level. Left at the center, balance should be fine with output tubes having a similar transfer characteristic. Use of a precision sinewave and an oscilloscope allows a more precise adjustment, and lower distortion.

The Capacitor Bank

Despite the limited room inside the Dyna chassis, there is enough room for capacitors storing almost 100 Joules of energy. The parallel connected bank of photoflash caps stores the energy needed, and eight caps inherently have a lower equivalent series resistance and equal energy storage than one or two larger value capacitors. The CAP Bank is mounted on half-inch length, 6-32 threaded metal spacers, fairly close to the steel chassis. It is strongly suggested that very small head 6-32 screws be used to mount that board to the spacer, or alternatively, beveled edge head screws that mount flush, or nylon head screws.

These methods would decrease the chances for the end-most caps of shorting to ground potential in the case of faulty insulation or internal leakage, which could cause a catastrophic meltdown. These screws can be found in the assorted parts box included with clone computers, likewise the short screws needed for mounting to the chassis. You may want to put an insulating mylar or plastic under this subassembly, since its high voltage could arc over accumulated dust to ground potential over time.

The CAP Bank is assembled on perfboard and the side-by-side assemblage is installed in such a way that a central strip of heavy buss wire forms a common ground point, with all eight minus leads connected here. As can be seen in the photo, the CAP Bank is mounted midway between the output transformers, right behind the voltage doubler/primary cap circuit board, well away from any heat sources.

Temperature tests (using the Fluke 52 digital temperature meter) have shown temperatures on the output tubes tend to be hottest near the physical center of the glass bulb (where it can be over 125° C), which would surely melt the cap insulation in no time and degrade or destroy the cap over time. Using this mounting technique, the tops of the caps are just about flush with the level of the tube sockets. In this way, the caps are spared the brunt of the hot air generated in that "upper" central area on the output tube's bottle.

Since the hot air rises, it will less likely affect the caps than if they were mounted higher up in the chassis. As each channel has an output tube fan, the hot air is directed towards the output transformer, and has nowhere to go but up and out of the amplifier.

Similarly, most electrolytic caps are units rated at either 85° or 105° Celsius. Photoflash caps are usually rated at 55° Celsius; mount them away from heat-producing parts and paths of hot air.

As a true DIY project, another innovation is that this massive CAP BANK is assembled from parts in discarded disposable flash cameras. These small flash cameras cost around $10.00. They are available from Kodak, Fuji Film, and other brands. They contain a small circuit board to which is attached a photoflash type capacitor, usually having a nominal rating of 160 uF @ 330 volts.

When the film is exposed, the developing facility pulls the film cartridge (a two-second process), then tosses the rest of the camera into the trash. I've collected about a hundred of these and removed the caps with minimal effort. I feel this is my way of helping the environment, and also saving some money. Similar photoflash caps can be purchased from suppliers, but often those are less space-efficient, and cost upwards of $8.00 each. A pair of 560 uF @ 400 volt caps (costing about $26.00 for the pair) can be substituted, if you can find them.

When disassembling disposable cameras — **!BEWARE!** — the caps in these cameras can be charged to high voltage, retaining that voltage for days, even weeks later! *It is possible to be shocked by handling these small flash circuit boards, a month after the battery is removed.* Find the cap leads and be sure to discharge the cap using a 68- to 220-ohm half-watt or larger resistor while holding the plastic camera, or by holding the circuit board by its edges.

I found that local Genovese Drug Stores and some of the one-hour photo shops (the ones that have actual photo-finishing machines on premises) will often impart to you a handful of these cameras for "recycling" into your project — for nothing more than the request and a polite smile. Others might ask you for the 5-20 cents for each camera that various recycling companies now pay them for sending back a big box full of these cameras.

Statistically, inside these disposable cameras,

Warning — Danger

As a precaution, one should be a MASTER TECHNICIAN to undertake this project. The voltages present in this project CAN KILL! Novices and weekend DIYs should consider this project beyond their expertise! NOT FOR FIRST-TIME BUILDERS. For those ambitious enough to attempt it, an expanded 25-page version of this article with over two dozen additional photos, will be made available direct from the author for $10.00 postpaid in the US.

More detailed construction manuals and a video tape are currently in preparation. Parts kits/subparts kits will also be available.

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Finding Dynaco Stereo 120s and Junker Chassis

This is a sporadic and often random endeavor. Sometimes I've seen both types on Rec.Audio.Marketplace in the course of a week. Other places to look include *Audio Shopper*, web auctions, web recyclers, and maybe the local TV/Radio repair places, or audio repair technicians in your area. Other times they don't appear for long periods. Some people have unrealistic ideas of what these things are worth, and if they do not sell, they get the idea, eventually. Supply and demand determines the price; the finite supply of the Dynaco Stereo-120 is approximately 120,000 units, most in the US, some in Canada, and Great Britain.

Of the last six Dynaco Stereo 120s I bought, only one was over $40.00; the last two were $25.00 each, plus shipping. One came from North Carolina, the other all the way from Japan! Neither one was completely functional, both were in very good cosmetic condition. Pricing tends to range from around the $5.00 level to around $70.00, depending on the cosmetic state and functional status. As they say ... Your mileage may vary.

FACTORY REBUILDS

The author will be producing a very limited number of rebuild amplifiers designated The BENDER-2pp amplifiers (also BENDER-3v. MK III's, and BENDER-1v. MK-I. MK-II. and MK-III.'s — these are single-ended triode amplifiers. The former using 10BQ5s, the latter Svetlana SV-811-10s). The BENDER-3v. MKIII uses the @ One-Electron UBT-1; The BENDER-1v. MK-II uses the UBT-2, The BENDER-1v. MK-I uses the Hammond Model 1628SE. The BENDER-1v. MK-III uses the Hammond Model 1629SE. These are available on a strictly limited, factory-rebuild basis for existing Stereo 120s. (Note: Rebuild means you send in a Dynaco Stereo-120 amp and you get your old chassis, cage, transformer, etc., parts back in the rebuilt amplifier.)

Owners of a suitable Dynaco Stereo-120 amplifier will need to send the amplifier — packaged in bubble wrap and properly boxed — along with a check and three mailing labels for processing.

An amplifier serial number will then be assigned, and our master technicians will rebuild it to the BENDER-2pp specifications designated in this article. For exact details, please send a SASE to the above P.O. Box address. The following web site should be operational by March 1997:

http://pages.prodigy.com/sbender/index.html

The BENDER-1v amplifier specifications and rebuilds are not yet available. Send SASE for details, or continue checking the web site.

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The BENDER-2pp Tube Push-Pull Amplifier Rebuild Project

there are five variations of capacitors. In all cases, a polarity bar denotes the minus lead. In any case, all these circuits put at least 330 volts on the cap, so they must handle at least 330 volts. Some are marked at 330 volts, some are marked at 350 volts, some are unmarked. On an early prototype, I did use a mixed set of eight dissimilar caps without encountering any problems, but to be conservative — and on the safe side — I'd suggest using a matched set of eight caps for the CAP Bank.

Caps designated: "photoflash" are designed for "high-frequency" operation; they are physically small and, as a result, they are not known for their capability in dealing with "low frequency" 60/120 Hz ripple. So, I strongly *do not* recommend mixing dissimilar types, or using "photoflash" designed caps right off the rectifier diodes on the power transformer. As used "downstream" after the high-voltage doubler's input caps (which are conventional electrolytics), there should be minimal ripple at this point, no adverse effects, and no problems.

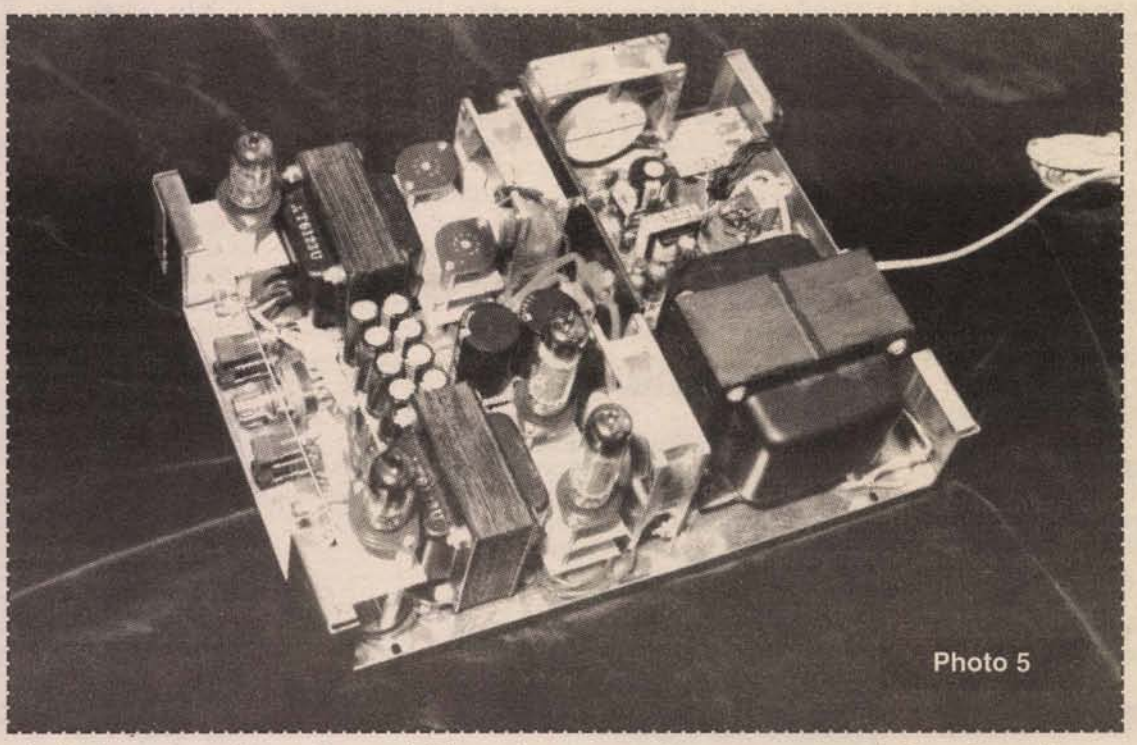

Photo 5

However, these caps are carrying high voltage, so the resulting CAP Bank should be carefully checked for caps that have excessive leakage to the case, odd capacitance values, or backward installed caps. If it is noted that any cap physically bulges, smokes, smells, or gets hot — *power down, and replace it immediately.*

The stereo amplifier must dissipate a certain amount of heat each hour. For a design using 5CZ6s, the filament dissipation is 5 volts x .6 amp times 6; which is 18 watts. The 10BQ5 scenario: 5 volts x .6 amps, times 2, plus 10.6 volts x .45 amps x 4 for 25 watts for the 5GH8/10BQ5 combination. To those power dissipations, one adds the quiescent plate dissipations to define the amount of heat to be dissipated into the air by the system.

Since a push-pull pair is strictly speaking *not* a Class A system, the plates of each output pentode should be below the 12-14 watt rated maximum level. The minimum 45 mA bias level, with six watts per output tube plate dissipation, is a reasonable figure to hope for, but may not work in practice. This adds 24 watts to the appropriate figure from above. Also appropriate is an additional 10 watts for the SPS supply and 10 more watts dissipated inside the power transformer. Results: 62 to 69 watts per hour, that's a lot of BTUs ... In other words, overall, the BENDER-2pp dissipates about as much heat as a 75-watt light bulb, maybe over 100 watts if the bias is set for higher plate dissipation. That is a lot of power within the confines of a small space.

Cool ... And speaking of cool, the BENDER-2pp needs unobstructed free air circulation. Since the output tubes do dissipate prodigious amounts of heat into quite a small space, internal temperatures can get a bit hot. That the final projects lacks fans, means there will be hot air rising from this unit — continuously. Keep all other books, papers, and audio equipment at least four inches from the chassis in all directions and never obstruct the cage holes or restrict air flow around the top, bottom, or sides of the chassis. And since the tips of all the tubes stick outside of the chassis, be extremely careful not to drop anything on it, which would decapitate the tops of the glass bulbs. Since the unit does weigh around 30 pounds, make sure whatever is supporting its weight, is capable of doing that over the long haul.

I have measured NOS sets of RCA, GE, Sylvania, Tung-Sol's, and Mullard tubes, finding only minor differences in measured performance. However, some sets do sound different from one another; some are "darker" for lack of a better word.

As noted, the circuit uses fast turn-on silicon diodes for the power supply. The reason for this is twofold: First, the five-volt line of the SPS probably couldn't handle the 275 volts B+ as a pass along voltage, since the SPS usually has output caps rated at or under 16 volts. Secondly, sadly, there was not enough room to put in that 5AR4, or 5U4s, and the primary filter caps, without the tube rectifier heat melting them. This leads to a question about plate/cathode stripping.

When the plate voltages on tubes are high before the presence of significant heater voltages, the thought is that the cathode gets "stripped" of its surface material by this high potential. As the heater eventually gets coated and becomes less efficient, I'm not sure if this heater-inhibiting oxide is supposed to be created partially out of particles from stripped cathodes, or what. Anyway, I'm not a firm believer in cathode stripping. Various amps, such as the rarely seen AcroSound Ultra Linear Stereo-120, and the Harmon-Kardon Citation II amps all use silicon rectifiers (and in the latter unit, as a voltage doubler as seen here), yet we hardly ever hear complaints about those and other vintage amps, either sonically, or regarding early tube death. I'd say it's a non-issue — use inexpensive tubes, replace them every six months, and be happy.

More Design Variations

For a more "old-fashioned" tube sound, it could still be built using carbon composition resistors and scrounged old caps, to impart that older style tube-sound to the unit. Use of fewer caps in the CAP Bank might muddy up the base or smear the sound somewhat. Use of scrounged parts, like from a discarded tube amp, Sprague Vitamin Q, or Black Cat caps from the 60s may change the sound significantly (and maybe for the worse). Using Infinity SET1 Wonder Caps may move the amp to a more pristine clarity.

Since the output tubes are pentodes, the amp designer has the choice of running them in true pentode mode, or changing to triode mode (with an attendant loss in power output). I find nothing really wrong with the sound of pentodes, as they provide the most power, all other things being equal.

Check carefully for cherry red glowing plates and a thermal runaway situation if you make any changes to triode mode or an "intermediate mode," such as using a high-value resistor between screen grid and the plate, like 4.7K ohms. Also, bad soldering has killed many a project. A word to the wise should be sufficient.

As a DIY project, the output transformers can be either store bought or scrounged from a discarded tube set from the 50s or 60s. Most defunct Fisher, H.H. Scott, or similar receivers and integrated amps using 6BQ6/7189/7591A, or 7868 output tubes would have appropriate iron in them, but not all would fit physically. My prototype was built using the output transformers from a Pioneer SX-110 receiver, which was dumped for the quite acceptable price of $18.00.

That Pioneer receiver used pairs of 7868 Novar Beam pentodes in the output and a 495 volt B+, so each push-pull pair should have been capable of around 35-40 watts into a 6,600 ohm load. The output transformers were probably rated for at least 30 watts, and should work fairly well in this lower power rebuild. An alternative transformer listed in the Parts List — Hammond's 1620 — is a 6,600 ohm primary/20 watt p-p unit of similar physical size, which should also provide a similar level of performance. The Hammond units have ultra-linear screen taps, to enable a distortion reduction process that junker transformers may lack.

Some old tube era deficiencies have been overcome in this design, specifically minor shifts in the filament supply, or bounce in the B+ line that cause discrepancies in operation, are corrected by using the SPS for the filaments and the CAP Bank for B+ energy storage. The stable SPS filament supply used here solves the first problem. For the latter, there are power conditioner transformers and on-line UPS units; or maybe complain to your local power company. Regulation of the B+ line was not done, as that introduces other problems, relative to the bias voltage, as the AC line undergoes its daily variances of higher and lower voltages. Regulating everything often gives too "sterile" a sound, and probably would be possible only in a unit having a much larger chassis.

Sonically, the output tap chosen from the transformer secondary reflects back into the output stage. In real terms, that speaker load reflected back on the tubes changing their operating points. Since there are no "correct" or "wrong" points on the graph to use (except going into or beyond cutoff), the static nominal operating point can be seen to be one of these reflected-back points of operation. The Pioneer transformers appear to have three secondary output taps (interesting, only two — 8 and 16 ohms are denoted on the units schematic). One of these three taps can be chosen, or a switch (break before make) capable of choosing any of the three could be installed. One additional note about the Hammond 1620 transformers: they have a strange wiring for the secondaries, and would likely not be usable with an output switch. On the 1620, you must choose one designated secondary wiring configuration and hard wire it in, as the existing secondaries are in series and parallel combinations for a given load. Listening will determine which is best for your speaker system.

Given an eight-ohm nominal load, use of the 16-ohm tap is likely to provide a back-generated signal higher than the nominal drive point — and less current drive — thus resulting in a lower distortion point. On the other hand, the four-ohm tap is likely to provide a back-generated lower impedance causing somewhat reduced output power and a more distorted operating point. I tried both variations, and the sonic differences were noticeable mostly in the amount of treble and upper mid-range detail.

Overall, I'd rate these differences as minimal. Since modern day speakers are 8 ohms (plus or

minus), that is the output tap most likely to be soldered to the five-way banana output jacks. This is a subjective stance: perform listening tests, wire the appropriate tap wire in your own chassis, or use a selector switch, as appropriate.

Preliminary Test Results of Design Variations

I'm not sure that the design as shown here is fully optimized in either the 5CZ5 or 10BQ5 incarnation. A likely point: the output tube's screen grid (G2) resistors value of 1000 ohms may not be the best value. The range of screen grid current should be 3-5 mA at no signal, with a typical maximum of around 10-12 mA. I didn't have time to try several different values and run additional tests.

The rated plate voltages can go to 350 volts for the 5CZ5 with G2 at 280 volts for a push-pull Class AB1 maximum of 21.5 watts output at 1% THD. The 10BQ5 design limit is rated at 300 volts for both plate and G2 voltages, in push-pull and a stated AB1 maximum power output of 17 watts at 4% THD. Both of these are close to the current configuration as can be seen from the included measurement charts.

Preliminary Functional Tests and Distortion Tests

Using the Pioneer output transformers from the defunct SX-110 tube receiver, the amplifier was tested in the "Open Loop," no feedback configuration. There were a few minor problems: First, the plate voltages were 25 volts lower than expected. This turned out to be a result of insufficient bias levels on the 5CZ5 channel. Originally, the bias circuit could be varied from 0 volts to around -12.5 volts. Later, it was re-designed to go from -5 volts to -32.5 volts, as is exists at the present time.

While the 10BQ5 channel was perfectly content with bias levels around -6 to -12 volts, the -10.6 volt bias present on the 5CZ5s caused them to pull too much current. This resulted in both tubes plates showing a stripe of orange/red. Under that condition, the 5CZ5's voltage on Rk was 3.75 volts for 175 mA of current for a combined plate dissipation of 46.4 watts — almost 200% of the maximum rated value. Charts 1 and 2 give measured plate dissipation values for a pair of push-pull tubes, measured in the amplifier under no-signal conditions.

As can be seen in Chart 1, even -32.5 volts appears to be insufficient for 5CZ5 proper operation. In comparing the two charts, one can see the bias voltages of the 10BQ5 are more "normal" in controlling plate current. The Sylvania Tube Manual's suggested 5CZ5's levels of -23.5 volts and zero signal 46 mA (46 mA per tube at 350 volts) current level did not occur within the limits of my circuit, even with the redesigned bias circuit. Extrapolating to that 92 mA level would require more like -37 or -38 volts of bias, so biasing the 5CZ5 appears to be a problem. Maybe my 5CZ5 tubes were gassy, and out of spec.

I noticed that they both had a bright blue glow under almost every operating condition. On the 10BQ5 side, the zero signal current (72 mA per tube at 300 volts) of 144 mA did occur at around -7.5 volts of bias, a much more workable value. While the project is still being worked on, the following measurements were taken in the "Open Loop" design, (e.g., no overall feedback). The unit was operating with a 1,000,000-ohm input impedance with 75 mV required to produce 9.8 volts across eight ohms, using the center (eight-ohm) tap on the output transformer secondary voltage gain was 42 dB in the Open Loop condition.

The 5CZ5 channel was operating with -32.5 volts of bias. Voltage was 4.59 volts (-2.3%) on the filaments. The power at clip point was about 10 volts/8 ohms. Clipping was reasonably symmetrical on both channels. Using 9.8 volts, or 12.25 watts output at 1 KHz, this channel produced 3.75% THD. The power bandwidth (-3 dB) points were: 28 Hz and 52,810 Hz at eight volts across eight ohms — the 10.0-watt level — the THD was 2.0% at 1000 Hz. The unit produced one watt at 2.7% THD at 1000 Hz. I noted that there was obvious crossover "notch" distortion on these signals, and much of these numbers are probably due to that crossover notch. This will be investigated as the design progresses.

The other channel using the 10BQ5 pentodes, needed 75 mV to produce 9.9 volts out. The bias was operating at the -31 volt limit. Plate voltage averaged around 290 volts on the plate with a 40 mA quiescent plate current at no signal. Filament voltage was 10.43 volts on the filaments (-1.6%). At 1 KHz and 12.25 watts output with -30 volts bias, the THD was 4%; -22 volts bias, 7%; -12.5 volts bias, 5%.

The circuit produced 9.93 volts before the clip point or 12.25 watts output at 2.85% THD at 1 KHz. Power bandwidth at that level (-3 dB) was 53,035 Hz and 27 Hz. At 10 watts, the distortion was 2.0%, which increased to 3.1% when the bias voltage was reduced to -12 volts. At 2.83 volts into 8 ohms (one watt), the THD at 1 KHz was 1.4%. The gain changed as bias voltage was reduced. The amplifier has not yet been tested in the closed loop configuration; more measurements will be coming, along with the schematic, in the last installment. **NV**

BENDER 2pp PARTS LIST

Input Stage Parts (*For Each Channel*)
(1) RCA jack (original or gold plated)
(1) 9 pin shielded ceramic tube socket
(1) 5GH8A pentode/triode tube
(1) 1.8" x 1.8" perfboard (cut to fit)
(1) 1" 4-40 F-F nylon spacer
(1) 1" 4-40 F-M nylon spacer
(2) 3/4" 4-40 F-M aluminum spacers
(2) 3/4" 4-40 F-F aluminum spacers
(5) 1/4" 4-40 pan head screws
(2) 160 uF/330 volt photoflash caps
(1) 2.2 uF/350 volt caps
(1) 47 pf polystyrene capacitor
(2) 15K ohm/1 watt resistors
(1) 1 meg ohm/1/2 watt resistor
(1) 330K ohm/1/2 watt resistor
(1) 220K ohm/1/2 watt resistor
(1) 150K ohm/1/2 watt resistor
(1) 3.9K or 4.2K ohm/1/2 watt resistor
(1) 1K ohm/1/2 watt resistor

Output Stage Parts (*For Each Channel*):
(2) 9 pin shielded ceramic tube sockets
(2) 3.2" x 1.4" perfboard
(8) 3/4" 4-40 F-M aluminum spacers
(4) 3/8" 4-40 F-F aluminum spacers
(10) 1/4" 4-40 pan head screws
(1) #4 ground lug
(2) .22 uF/400 volt capacitors
(1) 1000 ohm/15 watt chassis mount resistor
(1) 22 ohm/1 watt resistor
(2) 330K ohm/1/2 watt resistors
(2) 270K ohm/1/2 watt resistors
(2) 1K ohm/1/2 watt resistors
(1) 100K linear pot/1/4 watt
(2) 5CZ5 or 10BQ5 beam pentode tubes
(1) Output transformer 20 watts p-p
(8) 6-32 1/4" screws, washers and nuts

Primary Power Supply Parts:
(2) 470 uF/250 volt electrolytic capacitors
(2) 1N4937 fast recovery type 600 volt/1 amp diodes
(1) 2.7" x 1.4" perfboard
(2) 300K ohm/1 watt or 2 watt resistors
(2) 150 ohm/15 watt chassis mount resistors
(2) 5/8" 6-32 F-F aluminum spacers
(4) 1/4" 6-32 pan head screws
(24") 16 amp braid wire
(24") 1/8" red heat shrink insulation
(24") 1/8 clear insulation

CAP Bank Parts:
(8) 160 uF/330 volt or 145 uF/350 volt photoflash capacitors
(1) 2.7" x 1.4" perfboard
(2) 3/8" 4-40 F-F metal spacers
(2) 1/4" 4-40 pan head screws
(1) 3" 16 amp braid wire
(2) Inline insulated fuseholders (GMA or AGX/AGC type)
(2) 250mA or 375mA or 500mA GMA or AGX/AGC type fuses
(24") 16 amp braid wire
(8") 1/8" black heat shrink insulation
(8") 1/8 clear insulation or heat shrink insulation

Filament Supply Parts:
(1) Switching power supply 25 watts or greater. 5V & 12V as appropriate. Overall Dimensions: 4" x 3".
(1) Negative Temperature Coeff. Thermistor 3.5 ohm @ room temp.
(2) 7/8" F-F metal spacers (mounting to chassis floor)
(2) 3/4" F-F metal spacers (for edge of "L" heatsink)
(2) 3/4" 4-40 pan head screws
(6) 1/4" 4-40 pan head screws
High voltage 300 volt or 600 volt hook-up wire — several feet.

BIAS Supply Parts:
(1) 2.0" x 1.5" perfboard
(1) 1N4937 fast recovery diode
(2) 10 uF/100 volt electrolytics
(1) 39K ohm/1/2 watt resistor
(2) 10K ohm/1/4 watt resistors
(3) 2K ohm/1/4 watt resistors
(2) 50K ohm/20 turn trimpots
(1) 5/8" or 3/4" F-F 6-32 aluminum spacer
(2) 1/4" 6-32 pan head screws
two feet of wire

MISC. - Dynaco Stereo 120 Parts:
Chassis, cage, power transformer
Lighted power switch, one "L" heatsink
Chassis mount fuse holder
AC power cord and strain relief
Two pairs: 5 way output jacks
Two RCA input jacks

Replacement 2A AGC standard blow fuse
150 volt/10A MOV varistor (wired on power switch)

OPTIONS:

Output impedance switch if used: 1" diameter switch with 5/8" or 3/4" knob. 2 pole/3 position, break before make type.

0.1 uF/400 volt caps & 68 ohm/2 watt resistors may be needed cross the output terminals depending on the output transformer.

MISC. Tools:
Wire cutters — several pairs for cutting holes in amp cage, this quickly destroys lessor quality cutters, and leaves sharp edges. Assorted hand tools/power drill and Dremel Rotory Power Tool w/1/8" drill, and assorted accessories including a silicon carbide grinding stone for working with sharp edges on metal parts.

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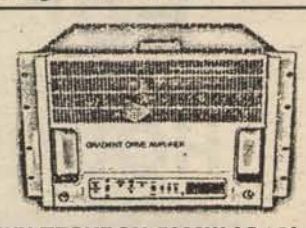

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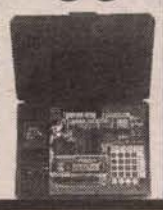

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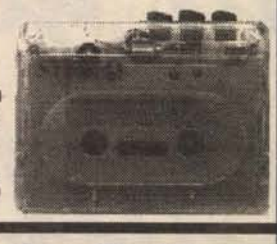

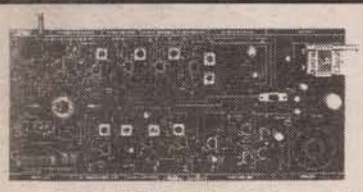

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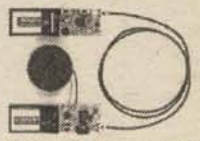

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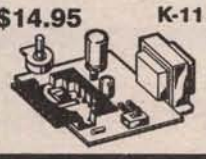

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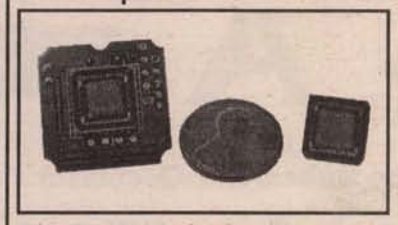

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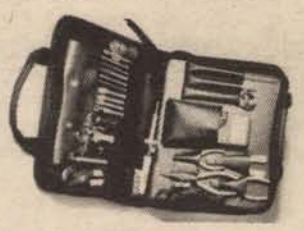

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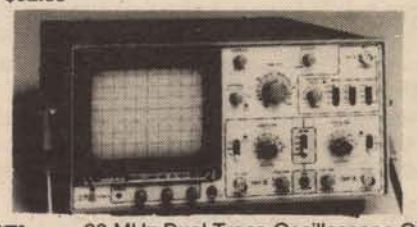

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ELECTRONICS Q & A

With TJ Byers

In this column, I answer questions about all aspects of electronics, including computer hardware and software. This column doesn't replace the Tech Forum that you've grown to love and support. Instead, it will supplement it, so feel free to participate as always with your questions and answers. You can reach me on America Online at TJBYERS, on the Internet at TJBYERS@aol.com or by snail mail at *Nuts & Volts Magazine*, 430 Princeland Ct., Corona, CA 91719.

Alphabet Soup

Q. I hate to bother you again, but I've been unable to receive the schematic of the motion detector circuit that you sent me. I get a lot of mixed letters and characters that make no sense whatsoever. My neighbor is a computer person (I am new to this) and his GIF files come through scrambled, too. He thinks that we're having problems because I'm on MSN and you're on AOL. Can that be?

Rich Gauger
via MSN

A. The reason why the file is coming through corrupted is because AOL automatically MIME encodes all binary files, such as GIF graphics and ZIP files. What you need to do is unencode it using one of the MIME decoder programs you'll find on our Web site at **http://www.nutsvolts.com**

DOS Shells

Q. Your December column used the metaphor of a "whirlpool" for the ABORT, RETRY, FAIL multi-cycle loop, and suggested adding the switch /F to the end of the SHELL to COMMAND.COM line in one's CONFIG.SYS file. My DOS manual states that switches and parameters so located are transferred to COMMAND.COM itself when it's invoked. However, my CONFIG.SYS doesn't have a SHELL line, and I'm not computer savvy enough to add such a line without lots of hand holding.

W. David English
via Internet

A. What SHELL does is provide a way home for DOS should you find yourself stranded in the twilight zone. Let's say, for example, you booted from a floppy disk. This tells DOS to look for COMMAND.COM at that location when it needs to access it. Now suppose you remove the boot diskette. The next time DOS needs to access COMMAND.COM, it can't find it. What you get instead is an error message instructing you to re-insert the boot floppy. The SHELL command tells DOS that there's another copy of COMMAND.COM at C:\, and that it should look there before issuing a warning. So don't be afraid to add the line

SHELL = C:\COMMAND.COM

to your CONFIG.SYS file. Use the EDIT command from DOS, open up CONFIG.SYS, and add the above line to the end of the file, then save and reboot. The line won't hurt anything, and can only help. Should you decide to upgrade to Windows 95, though, these extension parameters don't mean a thing. Windows 95 provides its own parameters (well, most of them), whereas Windows 3.1 doesn't.

Purple Haze?

Q. I have a generic VESA Local Bus VGA controller that has a Cirrus Logic GD5426 chip and 1 MB of memory. In terms of speed and performance, the board is great. However, everything on the screen has a red "shadow" that extends to the right of the original image, and all graphics have a blue tint. I'm sure the monitor and motherboard are both okay. I have no experience with display products (electronically speaking, that is), and I'm stymied as to what could be wrong.

Michael Harrington
via Internet

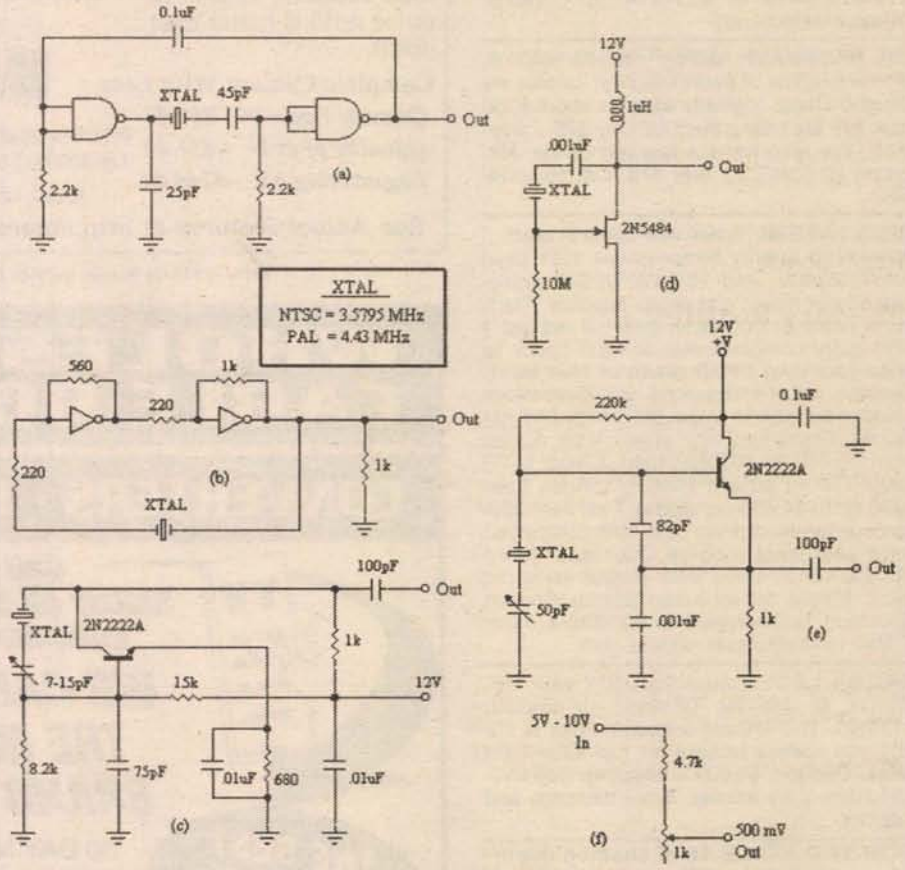
A. I've had very bad luck with VLB adapters, especially video cards. It sounds like there's a phase shift in your video signal. First, is the video cable okay? If so, try moving the board to a different slot. Remember that you're working with three sockets, and the one closest to the front of the machine is the most important. So make sure the board is properly seated. You might want to polish the contacts with rubbing alcohol and a cotton swab while you're at it (NEVER use an abrasive, like sandpaper or pencil eraser, to clean contacts). Beyond that, there's little else you can do except to replace the card (assuming the monitor is working). Hopefully, it's still under warranty.

Video Subcarrier Oscillator

Q. I'm looking for a way to generate a clean sinewave (with minimal distortion) of 500 mV to 1000 mV (peak-to-peak) at frequencies of 3.5795 MHz (NTSC) and 4.43 MHz (PAL) for use as a subcarrier signal in a video circuit.

Mass
via Internet

A. You're in luck, pal (sorry, I couldn't help myself), because you can buy crystals for these frequencies anywhere in town, which make this a very simple and flexible design. Since you didn't specify your operating parameters, I'm serving up a sampler for you to choose from.

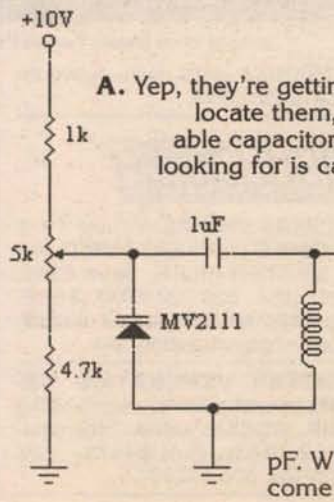


Circuits **(a)** and **(b)** use 7400 and 7404 TTL gates biased in their linear regions. The crystal provides the feedback. Oscillation can only occur at the crystal's fundamental frequency; overtones are not generated. Circuits **(c)**, **(d)**, and **(e)** are classic Colpitts and Pierce oscillators built around a junction transistor or FET. Circuit **(f)** is a voltage divider that reduces the output of these oscillators to the 500-mV signal you require.

Varactor Replaces Variable Cap

Q. I'm in need of a 75-100 pF variable capacitor and I can't find a company that sells them. I've looked all over. I could use the names of a couple of companies that still make them.

Ryan O'Grady
via Internet



A. Yep, they're getting harder and harder to find, and when you do locate them, they cost an arm and a leg. One source of variable capacitors is Digi-Key (**800-344-4539**). The part you're looking for is catalog number SG3011-ND. The reason you're having problems locating these components is because they've been largely replaced by varactor diodes. In fact, here's a simple circuit using a Motorola MV2111 (Allied Electronics, **800-433-5700**) that should work in your design. This diode has a capacitance of 47 pF at 4 volts. As the voltage across the diode increases, so does the capacitance; 8 volts is about 100 pF. While this circuit uses a single-ended varactor, they come in both single- and double-diode configurations.

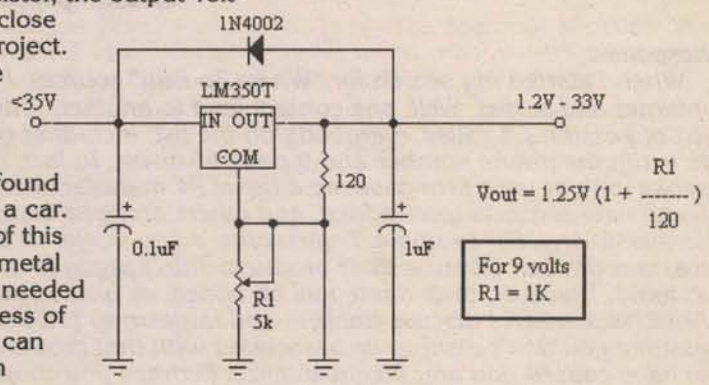
9-Volt Regulator

Q. I have a project that requires 9 volts to operate. I'd like to install it in my restored Chevy Luv mini-pickup, which has very limited cab space. Consequently, I need a small circuit that can reduce 12 volts to 9 volts. My problem is that I can't find a 9-volt voltage regulator. I have access to 5-volt, 8-volt, and 12-volt regulators — everything but 9 volts. Any suggestions?

M. Hillman
Mancelona, MI

A. Well, Radio Shack sells a 7809, which is a 9-volt voltage regulator. However, it's only good for 1 amp. You didn't say how much current the device will draw, so I'm guessing you'll probably want 3 amps, which allows us to use the versatile LM350T voltage regulator instead.

The LM350 adjustable voltage regulator is capable of supplying in excess of 3A over a 1.2-volt to 33-volt output range. It's exceptionally easy to use and requires only two external resistors to set the output voltage. If you replace R1 with a 1K fixed resistor, the output voltage is 9.3 volts — close enough for your project. The capacitors are added to improve the regulator's response to transients commonly found under the hood of a car. The bulkiest part of this design will be the metal heatsink, which is needed for currents in excess of 250 mA. All parts can be purchased from Radio Shack.



Mystery Rectifier

Q. Recently, my power supply fizzled and stopped working. Thanks to your article on "PC Power Supply Repair" that appeared in the September issue of *Nuts & Volts Magazine*, I was able to find the culprit. It is one of the rectifiers in the low power section. However, when that part went, its nomenclature disappeared too, leaving me unable to determine whether it was the 5-volt or the 12-volt rectifier. I have a copy of Digi-Key's catalog and tried to determine it from there, but was unable to do so. I would appreciate your help in finding out what this mystery rectifier is.

Howard Lee
via Internet

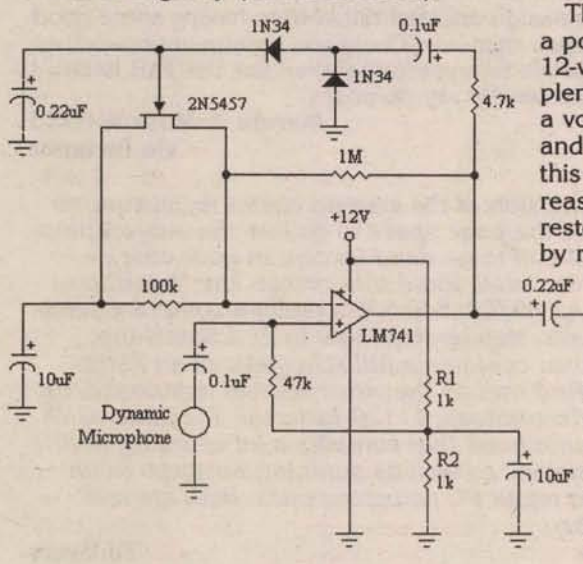
A. Look at the color of the wire the rectifier is feeding. If the wire is red, it's the 5-volt rectifier (Digi-Key MBR3045PT-ND); if the wire is yellow, it's the 12-volt rectifier (Digi-Key FEP16BTGI-ND).

Microphone Compressor

Q. I found an old schematic (70's vintage) of a microphone compressor. I'd like to build an updated version of this project that runs off a single-ended power supply.

Don Nappo
Stanton, NJ

A. The circuit you sent me is definitely dated because they quit making 1N60 diodes probably before you were born. However, the circuit is very solid and works well. So, the first thing to do is replace the obsolete semiconductors with modern equivalents. The only critical components are the 1N34A diodes, which are germanium — not silicon. All the parts are available from Radio Shack or Digi-Key (**800-344-4539**).



The original design used both a positive 12-volt and a negative 12-volt power supply, which were plentiful in those days. By adding a voltage divider — resistors R1 and R2 — we can easily make this circuit run off +12 volts. The reason for adding the divider is to restore the op amp's symmetry by referencing the non-inverting input (+) to an artificial ground. Because the operating voltage is now lower, the dynamic range is somewhat less than the original circuit. However, you'll still get 20 dB to 30 dB of compression, depending on the microphone used.

Compaq Has Flakey Floppy

Q. I have a Compaq ProLinea 3/25 with two dead floppy disk drives. All tests show that the floppy disk controller on the motherboard is the problem. So, I picked up a 16-bit IDE controller card to replace it. My problem now is: It didn't come with any documentation or company name. The only ID I can find is PTI 227B. When and if I get any info on this card, what do I need to do to disable the Compaq on-board floppy disk controller? I've tried to do it via the setup, but there's no provision for the new card.

Al Eisenhaur
via Internet

A. According to my local Compaq service center, you can disable the floppy disk controller via a jumper. The jumper settings are listed inside the lid of the cabinet. About the card, have you looked at it? Many times the jumper settings are silk-screened on the board. What you want to do is enable the floppy disk controller, but disable the hard disk controller. If the card is new, you'll have two hard disk options, which let you install up to four hard drives. Make sure both are disabled. And that should do it. Of course, you'll have to transfer your floppy drive cable from the motherboard to the new controller, but you already knew that.

Quiet!

Q. I live within a couple miles of a local AM transmitting tower. When I'm in my lab using the oscilloscope to measure low-level signals, the radio station blows away the signal, making it a nightmare to troubleshoot audio equipment. I've tried inverting channel B and using the ADD function to cancel the AM signal and switching the scope to HF rejection, with no luck. I have good equipment and well-shielded probes. Is there any way to filter out this 830 KHz signal with a circuit between the probe and the scope?

Todd Krueger
Coon Rapids, MN

A. It's not the scope that's picking up this transmission, but the wiring and semiconductors in your circuit under test. The interconnecting wires serve as antennas and the PN junctions in the semiconductors make perfect AM signal demodulators, which is what you're seeing — not the 830-KHz carrier. So filtering this frequency won't solve the problem. The only solution I can think of is to shield the audio equipment using a Mu-metal box or something equivalent.

Where Is It?

Q. In the Feb. '97 issue of *Nuts & Volts Magazine* (page 96) you mentioned a modem doctor software program, called MODEMD60.ZIP, that I could download from your Web site (**http://www.nutsvolts.com**). However, I can't find it. Did I miss it?

Matt & Jodi Schilf
via Internet

A. Sponsoring a Web site is both a boon and a bane. Yes, it gives our readers access to information and files mentioned in the pages of *Nuts & Volts Magazine*. But like most Web sites, it take a great deal of time to post files, update indexes, etc. Unfortunately, it doesn't always happen on time, which is why you may not find the file you're looking for when you log onto our FTP library. If you're in a hurry, nearly all these files can be found on the Internet — that's where I get a lot of them. Search for the file by the name listed using a good browser, such as MetaSeek or Lycos. Of course, you can always ask me to send a file to you, but in return I expect a Reader's Tip for payment. Well, not really. I'll send you the file no matter, but if you provide a tip, we'll pay you $25.00 if it's published. All suggestions — hardware, software, and whatever — are welcome.

MAILBAG

Mr. Byers:

I am a student of electronic engineering at a local university here in El Bosgue, Venezuela. To get my final degree, I need to present a thesis related to new technologies on the market. I happened upon your article on DSVD modems in the Aug. '96 issue, and believe that a project covering the DSVD technology would be of great interest to me and the university.

Since I don't have an easy way to obtain state-of-the-art technical information in this part of the world, I'm asking you the great favour of helping me find names, addresses, and Web sites where I can obtain information on DSVD technology, plus anything else you might think would help the effort. Many thanks in advance.

Luis Manuel Belo
Av. Libertado
Res. 24 De Julio
Piso 2, Apto 2B
URB. El Bosgue, Venezuela
582-975-00-42 (fax)

Response:

I'm always willing to help persons who wish to improve themselves and

the lives of those around them. But I can't take on something this big all by myself, even though I know the subject quite well, so I'm asking our readers if they can pitch in and give this young man help with his education by translating journals you may have into Spanish or providing DSVD contacts that you may know of. Thanks, everyone! Now let me kick this off with my two-cents worth. Here's a short list of DSVD-related Web sites.

TJ Byers

http://www.nutsvolts.com
The original Intel DSVD specs. It's now out of print and obsolete, but builds a good foundation. Download file DSVD17W6.DOC.

http://www.rsacode.com/
Check out what RSA and Cirrus Logic are doing in the 56Kb modem arena — technical papers presented to the Telecommunications Industry Association Committee TR-30.1.

http://www.usr.com
A whitepaper on 56Kbps over analog lines.

http://www.multitech.com/patents.htp
Multi-Tech Systems, Inc. DSVD Patent Information.

http://www.nb.rockwell.com/modem_report/may95/ModemReport.html
Rockwell modem support with FAQs.

http://public.att.com/press/0795/950707.mea.html
AT&T offers DSVD and speakerphone modem chipset in Europe.

http://www.hayes.com/
Hayes modems homepage.

http://www.bocaresearch.com/support/dsvd.htm
What is DSVD? from Boca Research.

http://www.datatechnology.com/dtc/products/dsvd/share.htm
This area provides you with the chance to download some of the best shareware games you can play with the DSVD modem.

http://www.sharkmm.com/dsvd.html
What's DSVD(Digital Simultaneous Voice and Data)? from SharkMultimedia; has WEB site links.

Mr. Byers:

I noticed in your Feb. '97 issue of Electronics Q & A a question on "Modem Troubles," where the reader couldn't make his Sportster 28.8 work properly. I had the same "problem" about a year ago. The problem turned out to be that I didn't upgrade the "wall-wart" power supply too! What made it truly strange is that both power supplies look exactly the same! With the Sportster 14.4, no problems. With the 28.8 on the 14.4 power supply, the modem lights up, but I couldn't get a dial tone. When I switched to the 28.8 supply, the modem worked perfectly and reliably. Hope this helps some of your readers.

Charles Dittell
cdittel@gate.net

Response:
Thanks for the feedback. I guess the Sportster 28.8 needs more power than the Sportster 14.4, which is causing the described behavior. The moral of the story is: Don't assume anything. Follow the directions exactly and upgrade all provided components.

TJ Byers
Q & A Editor

Mr. Byers:

I wish you would check with a company before listing it as a source for your "Where to Buy" on page 43. I do not wish to have our company listed for general public contact, especially for small systems. Photovoltaic Resources International has always been an engineered systems manufacturer, not a supplier of parts. The telephone number and address listed are out of date, the telephone is now being used for other purposes, and the address of the corporation is as listed for official purposes only. We have offices and production facilities as shown below. Please do not list us again.

There are some technical problems with your article. Most PV modules are generally designed for and rated for maximum power output at 16.5 to 17.5 volts at a cell temperature of 25C (78F). In operation in full sun, the maximum power voltage reduces to about 14-15 volts due to temperature coefficients. Some modules are designed as "self-regulating" with fewer cells per module, but these generally give disappointing service.

I mention this because in estimating the output of a module you must divide the power (corrected for the negative temperature coefficient of .5%/ deg. C) by the operating voltage of about 15 volts (14.2 + 0.8 for blocking diode + some wire loss), not the 14.2 value you used. This current is generally close to the rated current at maximum power point and somewhat less than the value you will get.

Also, your statement "Unless the battery is exercised, the plates will sulfate and suffocate the battery" is not correct. Lead-acid batteries like nothing better than to be floated at the proper full charge voltage of about 2.35 volts per cell. Ask any lead-acid battery company.

Sulfation happens at a low state of charge. Only ni-cd batteries are damaged by non-cycling or shallow cycles.

When sizing a battery for PV applications, the general rule is to use the battery capacity at the end of its life (typically when capacity is 80% of rated) in the calculations. This is detailed in the standard ANSI/IEEE 1013-1990 "IEEE Recommended Practice for Sizing Lead-Acid Batteries for Photovoltaic (PV) Systems." At some point, I suggest you tell your readers to see Article 690 of the National Electric Code for some safety requirements.

William Kaszeta, President
Photovoltaic Resources Int'l
1902 N. Country Club Dr. Ste. 6
Mesa, AZ 85201
E-Mail: pvcad@primenet.com

Response:
When I started my search for "Where To Buy" sources, I jumped on the Internet and surfed. Well, one contact lead to another, until I had a long list of possibles. I called everybody on the list, including your company, to verify the phone number and type of business. In fact, the person I spoke with at your firm gave me a list of PV manufacturers you represent. Some new contacts were added, and others dropped because of these conversations. For example, Zomeworks, a key player in the solar industry, was omitted because their products didn't apply to the current project at hand. However, their name will be added, as well as others, in the April issue when I discuss trackers and large-array (10 kW+) issues. But I assume you don't want to be associated with that crowd either. I'm sorry to have caused you any inconvenience. Perhaps you should surf the Internet yourself and ask other providers to remove similar references to your company. That way you can go about your business unbothered.

Concerning your statements about photovoltaic-array power specifications, you're confusing the issues. A solar cell can output 0.7 volts under ideal conditions, which is how the vendors like to spec their panels. In real life, though, it's more likely 0.45 volts under load. What the battery is looking at, though, is current, not voltage. A nice thing about photovoltaics is that it's a constant current generator, which means it delivers, let's say, 3.08 amps, whether the voltage is 16 volts or 10 volts. It doesn't care. And neither does the battery, because it's current operated, too. So, I've simply boiled down all the math of temperature coefficients and mumble jumble into a simple rule-of-thumb formula. In short, I'm presenting real-life solutions that don't take a rocket scientist to figure out. If you want to know more about photovoltaic theory, sit in on next month's N & V Solar Workshop Classroom.

TJ Byers

Mr. Byers:

I enjoyed your article PC Power Supply Repair article in the Sep. '96 issue of *Nuts and Volts Magazine*. It is probably the best article that I have found on the subject. May I make a few comments?

1) I have an AT-style switching power supply that has a pair of 2SC4242s in the primary and a TL494 IC in the secondary which matches your article quite closely. However, my problem is start-up. If I momentarily touch +15 VDC to Vcc of the 494, I get a well regulated clean output from all voltages. I did check the diodes and caps in primary and they seem to have good capacity and low ESR. What I don't see is the start-up path from the primary to the 494. You didn't mention this in your article. Do you have a complete schematic?

2) There's no comment on the two books mentioned in your article. I hate to spend $40.00 on a book that is design oriented rather than having some good schematics that are practical repair manuals. Could you comment on whether the two books are really appropriate to repair rather than like the TAB books that I have found to be totally useless for my purposes.

Marvin J. Moss W4UXJ
via Internet

Response:
The reason I limited my discussion of the start-up circuit is because no two are alike and I didn't have the page space to go into the subject properly. It's also the least likely circuit to go dead (except in your case). Fortunately, both books go into detail about this circuit. The "book" by Jim (P.O. Box 5123, Tucson, AZ 85703; $40.00) is really a computer printout on fanfold paper that details, step-by-step, how to fix a switching power supply. This manual even contains a full schematic of an Astec 250W PS, which you should find useful. The other manual mentioned, by WELX Technologies (Grafnet Technology, 11120 Tattersall Tr., Oakton, VA 22124; $20.00), is a spiral-bound book that contains a lot of theory on the operation of diodes and transistors, as well as outlining the steps (with plenty of drawings) needed to repair PC power supplies. Both are welcome additions to a fix-it library.

TJ Byers

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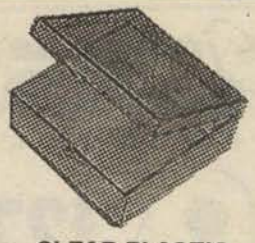

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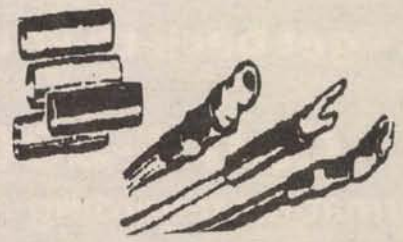

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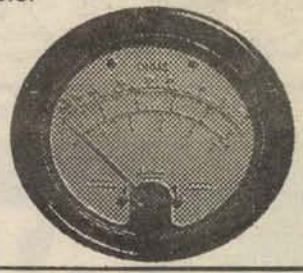

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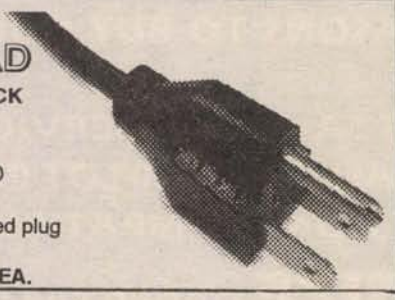

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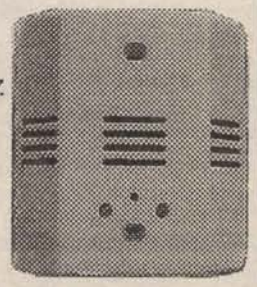

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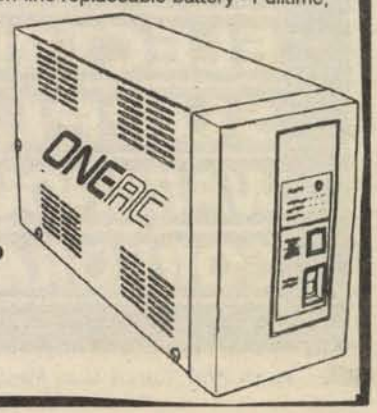

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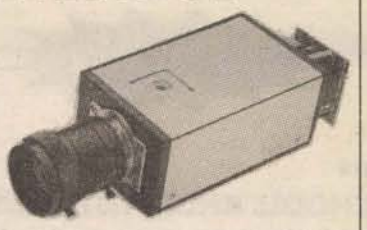

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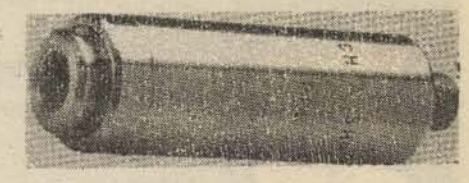

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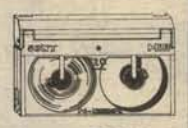

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AMATEUR ROBOTICS

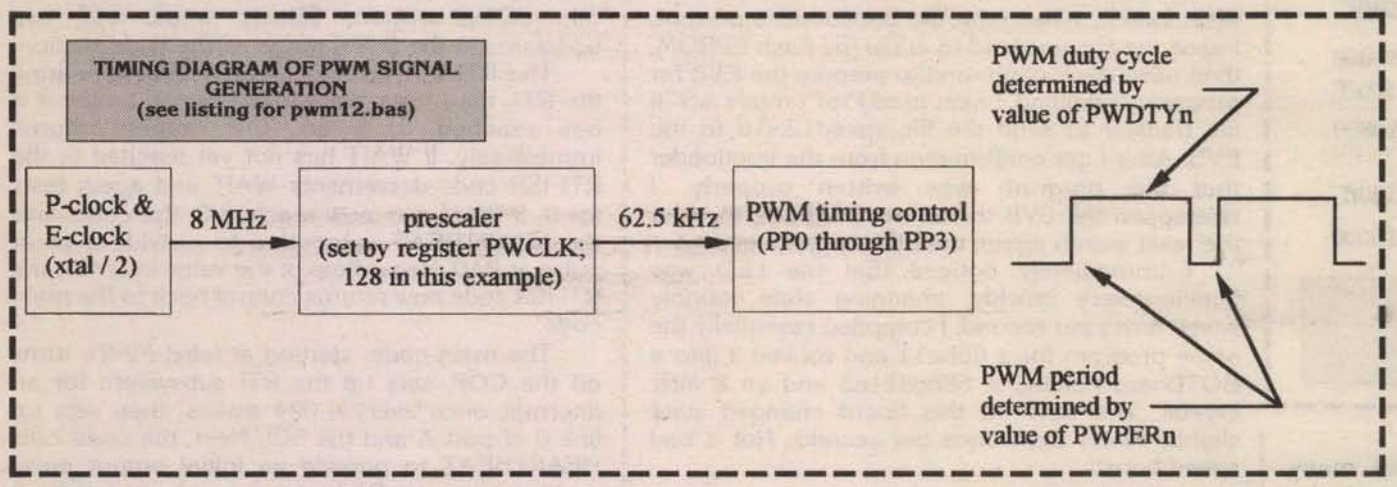
by Karl Lunt

Checking out the 'b32

Motorola's latest variant of the 68hc12 hit my workbench just before Christmas, and I've had several weeks to play with it. The 68hc912b32 — I can safely predict — will cause a huge sensation in the amateur robotics community.

This 80-pin TQFP chip uses a 16-MHz crystal to generate an internal system clock of 8 MHz, giving you an immediate 4x speed boost over the older 68hc11. Add the improved addressing modes and spiffed-up instructions, and your 68hc11 code will run up to 10 times faster on a 'b32. Even better, the 68hc12 opcodes are source-compatible to the 68hc11, so you won't even have to edit the opcodes in your assembler source files.

Three members of the Seattle Robotics Society were privileged to test-drive both the 'b32 chip and a new evaluation board (EVB), courtesy of Motorola. Kevin Ross focused his efforts on connecting his newly designed Background Debug Mode (BDM) board to the 'b32. Marvin Green used his 'b32 chip as the core for his newest BOTBoard-style prototyping tool: a small single-board computer (SBC) for the 'b32. And I spent my quality time porting SBasic to the 68hc12 so I could write actual 68hc12 software and test my programs on a working EVB.



Inside the 'b32

Like its older cousin — the 'a4 — (discussed in this column some months ago) — the 'b32 sports many of the newly designed I/O subsystems common to the CPU12 chipset. Besides the CPU12 core, with its enhanced addressing modes, fuzzy logic instructions, and 20-bit ALU, the chip handles 8- or 16-bit expansion busses, has eight channels of fast 8-bit A/D, eight 16-bit timer/counters, a 16-bit pulse accumulator, hardware-generated pulse-width modulation (PWM), an SCI for asynchronous communication, an SPI for synchronous I/O, and CPU12-style BDM.

But the real killer feature of this chip — as far as amateur robotics is concerned — lies with the on-board memory resources. The "9" in the chip's part number (68hc912b32) indicates that the device carries flash EPROM. In fact, it holds 32K bytes of flash EPROM, plus 1K of static RAM and 768 bytes of the more common EEPROM. This means the chip can handle very large programs without having to use an expanded bus, with the attendant loss of valuable I/O lines.

Even cooler, the 32K flash EPROM, which sits at the top half of memory, comes preloaded with a 1K byte bootloader. This program lets you download S19 records via the SCI serial port at 9600 baud, using a conventional communications program such as ProComm. Thus, getting your program into the 'b32 takes little more than resetting the board, then doing an ASCII file download from ProComm. As simple as pcbug11 is for the 68hc11, the 'b32 bootloader is simpler still. And the 32K flash is protected with a lockout, so your development code can't trash memory if it "runs away" during test.

The bootloader itself sits in the very top 1K of memory and is protected with a second level of lockout, so you cannot accidentally overwrite it with a file transfer or code runaway. If you really do want to overwrite the original bootloader with your own code, you can do so via the BDM. Likewise, you can use the BDM port to restore the bootloader if you so choose.

But those are possibly the only times you would really need to use the BDM. In general, you can do everything you need to do with the 'b32 using nothing more than a serial connection through the SCI. This is a huge boon to experimenters, opening up access to this way cool chip without the expense and fuss of an additional BDM board.

Motorola also sent me a prototype of their new 'b32 EVB, part number M68EVB912B32. This board measures 3.5" by 5" and contains a good-sized prototyping area, a MAX562 RS-232 level-shifter, and the 'b32 chip proper. The rest of the board space holds the needed passives and pullups to drive a 'b32 in single-chip mode, plus an assortment of jumpers. It also has a fancy lever-type connector for +5 VDC, a two-pin header for the +12 VDC needed to program the flash EPROM, and a nine-pin RS-232 connector for hooking to your host computer.

Sources inside Motorola tell me that the board should be ready for release by the time you read this, with a projected price tag of less than $100.00. I consider this an excellent price for the quality design I've got sitting on my workbench, and wouldn't hesitate to buy one. Contact your local Motorola distributor for pricing and availability.

SBasic and the 'b32

I wanted to jump in immediately and begin writing code for this chip, but the only software tool I had was my as12 assembler. Granted, this freeware assembler, available from my web site at www.seanet.com/~karllunt is good enough for simple programs. But I didn't want to get bogged down in assembler programming, I wanted to play. And I play best in SBasic.

So I spent a precious week or so editing SBasic so it would generate output code for either the 68hc11 or the 68hc12. I didn't go so far as to change the code generator so it would use the nifty new opcodes. I settled instead for rewriting the generator so it would output 68hc11 assembler source compatible with my as12 assembler. This takes advantage of the source-level compatibility between the two devices.

You can get a copy of my latest SBasic compiler — version 2.0 — from my web site (see above). You control which chip the compiler uses as a target by means of a command line option. To compile for a 68hc12, invoke SBasic with a command such as:

```
sbasic foo /m6812
```

This compiles the file foo.bas and generates code for the 68hc12. If you leave off the /m option, you get code for the 68hc11 by default.

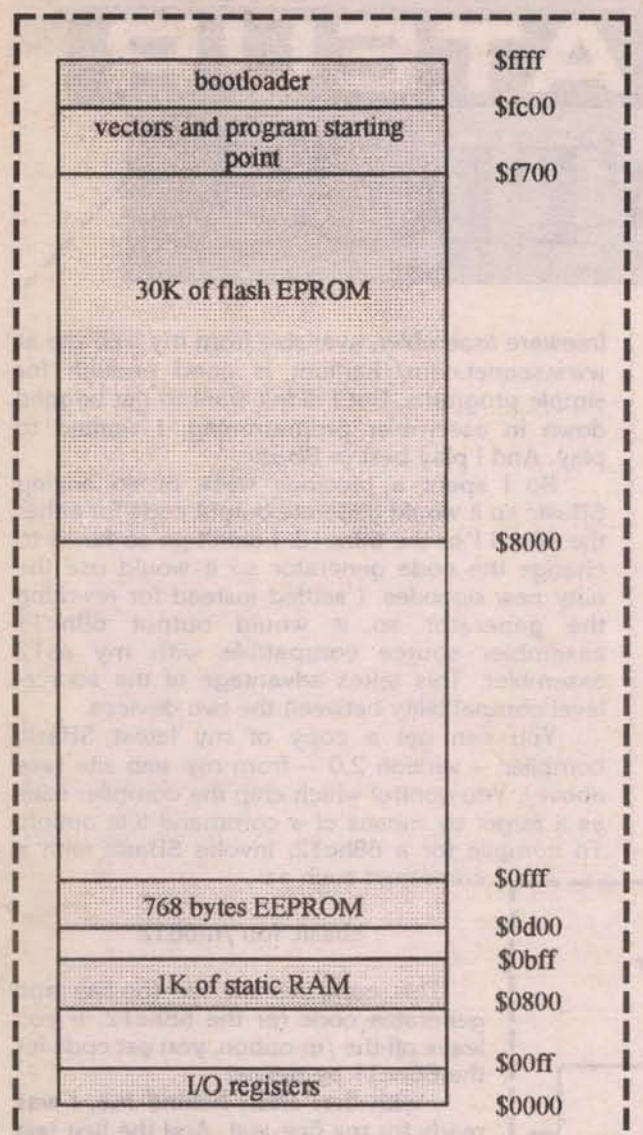
With that effort behind me, I was ready for my first test. And the first test I do with any new chip is a standard, blink-the-LED speed test. So I hooked a 470-ohm resistor to the anode of an LED, wired the LED's cathode to ground, and ran a wire from the other resistor lead to I/O pin PB0 on the 'b32 EVB. This gives me a simple LED indicator that lights when I bring PB0 high, and goes dark when I bring PB0 low.

Next, I had to dig through the preliminary docs on the 'b32, supplied by Motorola with my EVB. The 68hc12 differs greatly from the 68hc11 with regard to programming the I/O registers, and I spent quite a while poring through the many pages.

The 68hc11 only has 64 I/O registers, many either reserved or not used. I know this seems like a lot of I/O registers to twiddle if you want the chip to perform but, for most programs, you will use a very small subset of this full collection. Contrast this with the 256 I/O registers used by the 68hc12, and you get a crude measure of the increased sophistication in this chip.

For example, port B on the 68hc11 is an output-only port. To affect the outside world using port B, you simply write a value to register PORTB, and the I/O lines change accordingly. On the 'b32, however, port B is bidirectional, so you must first modify register DDRB — the port B data-direction register — to assign each pin as either input or output. If you intend to use some of these lines for input, you next want to alter the pull-up control register (PUCR) to enable or disable the port B internal pullups. Likewise, you need to select either reduced or full drive level for port B output pins, using the RDRIV register. Finally, you can write a value to register PORTB to change the outside world.

Having gathered all this information together, I was ready to write my first 68hc12 SBasic program. See the accompanying listing of



68hc912b32 MEMORY MAP (single-chip mode)

speed12.bas.

This program, though small, shows many aspects of 'b32 software. I compiled it with the command line:

```
sbasic speed12.bas /s0bff /cf700 /v0800 /m6812 /i >speed12.asm
```

which sets the stack at $0bff, the variables at $0800, and the code at $f700. The code setting, in particular, is important. The bootloader in my 'b32 EVB takes control immediately after reset and tests the state of two I/O lines. These lines, tied to jumpers on the EVB, determine the bootloader's function. When the bootloader detects that the EVB is strapped to run a user's program, it automatically jumps to $f700 after reset. Thus, you have to set the start of your code at $f700 if you want it to run.

This command line also shows the new /i option. Normally, SBasic automatically adds the reset vector (and any other interrupt vectors you select) to the 68hc11's vector area at $ffc0 to $ffff. Since that area of memory is locked out in the 'b32 and cannot be modified with a simple program download, I added this option to completely supress generation of interrupt vectors. This option comes in handy when I need to install vectors in another address area, as I will when working with the 'b32.

SBasic compiles all programs to begin execution at the address given by any /c option. If you choose, you can add ORG statements inside your SBasic program to move later code to a different address, as I've done in speed12. This combination of the /cf700 option and the ORG $8000 statement lets me put the start of my program where the bootloader wants it, yet store the bulk of the program down at the beginning of the 'b32's flash EPROM, where I want it.

Like all SBasic programs, my code actually starts at the required label MAIN. Here, I begin by disabling the COP watchdog. I could have chosen to repeatedly service the COP, preventing it from timing out and resetting my program, but I wanted this to be a simple test so I just disabled the COP.

Next, I modify the three main registers associated with the 'b32's SCI port. My initializations set the EVB for 9600 baud, 8N1, and enable the SCI. Then I print a greeting to the serial port so I know the program at least got that far. I follow this by setting up PB0 as an output pin and enabling full output drive.

Now I'm ready to begin toggling PB0 so my LED changes state. I used an infinite DO-LOOP structure around a FOR-NEXT loop that counts from 0 to $fffe, unsigned. Thus, the LED will change state each time the loop counts past 65534. It's important that my FOR-NEXT loop end at $fffe and not $ffff. SBasic FOR-NEXT loops terminate when the index variable exceeds the limit value, not when it reaches it. Using a limit value of $ffff would actually create an infinite loop, since the index can never exceed $ffff.

After compiling the program, I hooked my EVB to the PC's serial port, fired up ProComm, strapped the EVB for bootloader mode, and hit the reset switch. When I got the bootloader's prompt, I used the E command to erase the flash EPROM, then used the P command to prepare the EVB for program download. I next used ProComm's ASCII file transfer to send the file speed12.s19 to the EVB. After I got confirmation from the bootloader that the program was written properly, I restrapped the EVB to run my program, then hit the reset switch again; the LED began blinking.

I immediately noticed that the LED was blinking very quickly, changing state roughly seven times per second. I compiled essentially the same program for a 68hc11 and moved it into a BOTBoard holding a 68hc811e2 and an 8 MHz crystal. The LED on this board changed state slightly faster than once per second. Not a bad speed boost!

Time for some PWM

But robots need more than time-wasting loops, and I wanted to take a look at the 'b32's brand-new PWM subsystem. The next robot on my horizon will need some PWM support for motor control, and I was curious to see how the new chip handled this task. My first experimental code appears in the accompanying listing of pwm12.bas.

This example is longer and more complex than speed12 above, but I think it is much more instructive; pwm12 sets up four independent PWM outputs, all running at the same frequency but with different duty cycles.

Before I walk you through the set-up, please note that the final waveforms are generated entirely in the CPU12's hardware subsystem. This complex waveform generation does not impact the CPU at all.

My program begins by declaring some needed variables, then using the ORG statement to move the code to $8000, as done above in speed12. Here, however, I added the second argument, CODE, to the end of the ORG statement. This option is new for version 2.0, and fills a subtle, yet critical need when writing code for this early version of the 'b32.

The 'b32's bootloader overlays the entire interrupt vector table, including the reset vector. Therefore, if your program wants to use interrupts of some kind — as pwm12 does — you have to use the jump table provided in the bootloader. This jump table re-routes all interrupts except reset through a table of addresses starting at $f7a0. Each entry in this table is three bytes long, allowing your program to insert a JMP-extended instruction to the location of your interrupt service routine (ISR).

My program uses the real-time interrupt (RTI) to decrement a variable once per interrupt, making that variable a down-counting timer. But to pass control to my ISR, I have to set up a JMP to RTIISR where the interrupt is serviced. The block of code following the RTIISR label services that interrupt, and the label RTIISR gives SBasic a way to refer to the address of the ISR.

But back to the CODE option in the first ORG statement. This option tells SBasic to mark its internal code section as now starting at $8000, rather than the $f700 as originally called out in the command line option. Any subsequent references to the CODE section in my program will refer to addresses in the $8000 range. This becomes critically important later, as you'll see. Without this CODE option, SBasic would still use addresses in the $f700 range as the code section.

The RTI ISR code is fairly simple. It re-arms the RTI, then tests the variable WAIT to see if it has reached 0; if so, the routine returns immediately. If WAIT has not yet reached 0, the RTI ISR code decrements WAIT and again tests for 0. If WAIT has now reached 0, the code calls the HEARTBEAT subroutine to provide a short pulse at PA0. Regardless of the value in WAIT, the RTI ISR code now returns control back to the main code.

The main code, starting at label MAIN, turns off the COP, sets up the RTI subsystem for an interrupt once every 1.024 msecs, then sets up line 0 of port A and the SCI. Next, the code calls HEARTBEAT to provide an initial output pulse and to make sure PA0 returns to a known state. It then issues a sign-on message, presets variable WAIT, and enables interrupts so the RTI can actually occur.

The next chunk of code initializes the PWM subsystem to provide pulses on all four PWM port output pins, labeled PP0 through PP3. These four pins are controlled by two identical PWM subsystems; the first handles PP0 and PP1, while the second runs PP2 and PP3. You can set up PP0 and PP1 as two separate 8-bit PWM counters, or concatenate them and treat them as a single 16-bit PWM counter.

You have this same option with PP2 and PP3.

Listing of speed12.bas

```
include "regs12.lib"
declare n
org     $8000
main:
pokeb copctl, $08                       ' disable COP resets and clock
poke sc0bdh, 52                         ' 9600 baud
pokeb sc0cr1, 0                         ' 8 bits, no parity, 1 stop
pokeb sc0cr2, $0c                       ' enable xmtr and rcvr
print
print "speed12"
pokeb ddrb, 1                           ' make PB0 an output
pokeb pucr, 2                           ' enable port B pullups
do
        pokeb portb, peekb(portb) xor 1
        for n=0 to* $fffe
        next
loop
end
```

end of listing

My code writes a value of $3f to register PWCLK so I can use all four PWM outputs as separate 8-bit counters. This value also assigns a clock prescaler value of 128 to the two PWM subsystems. Since the PWM clock is derived from the CPU12 P-clock, running at half the crystal frequency, this yields a PWM basic clock rate of 8 MHz divided by 128, or 62.5 KHz.

Writing a value of $00 to register PWPOL selects the proper clock source (described above) to the two PWM subsystems. It also defines the PWM outputs as active high (resting low). My code then writes $02 to register PWCTL; this enables the pullups on all PWM output port pins.

Next, I have to set the actual PWM period and duty cycle. Since I'm using all PWM channels in 8-bit mode, the period of each PWM waveform is controlled by a separate 8-bit register. I'll describe the arrangement for PP0; the other three channels operate identically.

The clock for PP0 is fed by the 62.5 KHz clock stream selected by my previous write to PWCLK. In left-aligned mode, used here, the period of PP0's PWM cycle is always one more than the 8-bit value written to register PWPER0. My code writes a $ff to PWPER0, which means the PWM period for PP0 is 256 cycles of the 62.5 KHz clock stream, or 4.1 msecs; this works out to a 244 Hz cycle rate.

I then assign the duty-cycle of PP0 by writing another 8-bit value to PWDTY0. Since I had already assigned this channel as active high, this value determines how long the PWM output stays high during each PWM cycle.

As with the PWM period, this value is measured in cycles of the 62.5 KHz clock stream. In my example, I used a count value of $40, which is 25% of a full-scale value of $ff, and yields a 25% duty-cycle. You can see that I also assigned duty-cycles of 50%, 75%, and nearly 100% to the other three PWM channels.

The last task remaining is to enable the entire PWM subsystem by writing the proper bit pattern to register PWEN. This final write activates all four PWM channels so the desired waveforms appear on the assigned output pins.

After activating the PWM subsystems, my code enters an endless loop that simply tests the WAIT variable, updating it as necessary. The value written to WAIT determines how much time elapses between each heartbeat pulse; the value I chose (977) provides a one-second delay, given the RTI interrupt rate of 1.024 msecs.

The only task remaining must be handled by the SBasic compiler, and that involves setting up the jump vector so control will reach the RTI ISR whenever an RTI interrupt occurs. This task is accomplished with the block of code following the ORG $f7e8 statement. After changing the ORG to $f7e8 — where the bootloader expects to find my jump vector for an RTI interrupt — I use an ASM block to assemble a JMP instruction to label RTIISR.

Following the assignment of the JMP opcode, I must make sure I use an ORG CODE statement to switch SBasic back to the main code section. After SBasic finishes compiling my program, it will append any needed library files at the current location. If I don't change back to the code section, SBasic will end up adding the library code to the interrupt vector area, which is incorrect.

Finally, we get to the real reason for using that first ORG CODE statement. If I had not added the CODE option to that statement, SBasic would now revert to its original code section, which started at $f700 as called out in the command line. SBasic would thus add the library code somewhere in the $f700 area, potentially overwriting the jump vector table at $f7a0 and above.

This, in turn, would cause a nasty crash when I tried to run the program. The bottom line is that you need to be aware of SBasic's behavior and of the 'b32's requirements whenever you design code for this new chip.

Having said all this, I'll point out that Motorola is re-designing the bootloader, and the final version of their firmware will likely behave somewhat differently. In particular, there is talk of going to a two-byte jump table, rather than a three-byte table. This will significantly change the way you set up an interrupt vector for the 'b32 in SBasic, making it more like the traditional 68hc11 technique of a single INTERRUPT statement with an address argument. Consult the Motorola docs for the bootloader that comes embedded in your chip for full details.

That's a wrap

This completes my first look at what I'm sure will prove to be a very popular chip. The 68hc912b32 offers 68hc11 code compatibility in a small chip with plenty of program space. The I/O goodies, including the PWM subsystem described above, make it a natural for small robots.

The embedded bootloader, which lets you download executable files with commonly available tools, will simplify your test and development cycles. And with SBasic's capability to generate 68hc12 assembler source files, you can quickly get your new programs up and running.

I'll keep you posted on further developments regarding the Motorola 'b32. Contact your local Motorola office, or a distributor such as Future/Active, for price and availability of both the 'b32 chip and its EVB.

And be sure to check the Motorola web site (http://Design-net.com/) now and then for new product information. **NV**

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Listing of pwm12.bas

```
include "regs12.lib"
const ONE_SEC = 977
declare n
declare wait
'
' Declare the location of the main code. Change the code
' section also.
'
org     $8000 code
heartbeat:
pokeb porta, 1
pokeb porta, 0
return

'
' Define the RTI interrupt service routine. Note that
' the INTERRUPT statement does not have an address argument.
' The actual vector will be set up in code later on.
'
interrupt
rtiisr:
pokeb rtiflg, $80                       ' rearm the RTI
if wait <> 0
        wait = wait - 1
        if wait = 0
                gosub heartbeat
        endif
endif
end

'
' The main program
'
main:
pokeb copctl, $08               ' disable COP resets and clock
pokeb rtictl, $81               ' 1.024 ms, RTI enabled
pokeb rtiflg, $80               ' rearm RTI
pokeb ddra, 1                   ' make PA0 an output
pokeb pucr, 1                   ' enable port A pullups
poke sc0bdh, 52                 ' 9600 baud
pokeb sc0cr1, 0                 ' 8 bits, no parity, 1 stop
pokeb sc0cr2, $0c               ' enable xmtr and rcvr
gosub heartbeat                 ' set up heartbeat line
print
print "pwm12"
wait = ONE_SEC
interrupts on
pokeb pwclk, %00111111          ' A/128, B/128
pokeb pwpol, %00000000          ' start all pwm channels low
pokeb pwctl, %00000010          ' active pullups, full drive, left aligned
pokeb pwper0, $ff               ' period count for pwm0
pokeb pwper1, $ff               ' period count for pwm1
pokeb pwper2, $ff               ' period count for pwm2
pokeb pwper3, $ff               ' period count for pwm3
pokeb pwdty0, $40               ' duty cycle for pwm0
pokeb pwdty1, $80               ' duty cycle for pwm1
pokeb pwdty2, $c0               ' duty cycle for pwm2
pokeb pwdty3, $fe               ' duty cycle for pwm3
pokeb pwen, %00001111           ' enable all pwm channels
do
        if wait = 0
                wait = ONE_SEC
        endif
loop

'
' Declare the interrupt vector jump table here, rather than
' at the end of the code. This keeps the library routines from
' being compiled in the vector area.
'
org $f7e8
asm
        jmp     _rtiisr                 use the SBasic label rtiisr
endasm

'
' Finally, return to the code section so the library routines will
' end up in the correct location (following the main program, not
' in the vector area).
'
org code
end
```

end of listing

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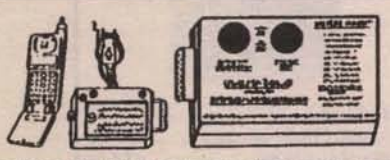

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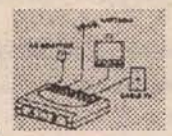
NORTHERN TELECOMM #2960 telephone network interfaces (RID/MTU). Easily converted into extension phone lockout. $1.50 each, $9.90 for ten, $59 per hundred. Full docs available. SYNERGETICS SURPLUS, Box 809, Thatcher, AZ 85552. 520-428-4073. VISA/MC.

MOTOROLA COPYCATS to version 951C w/elite, $900, **EE3/961C** w/elite and Startac ESN clip, $700, both $1,500. **GE-ERICSSON** (95W40) ESN clip, does most silverbacks, $250. **OKI 900 5 NAM** phone $450, chip for mod, $150, blank chips $35 (original Toshiba). **CTEK** interface w/software $150. **ASK FOR PRICES ON READERS. CALL FOR COMPLETE INFO 1-800-607-1745 9-5 PST.**

OKI 900/1150 experimenters cables for sale, connects your phone to any PC via serial port. Allows you to experiment with many of the OKI's hidden features. Software not included but available off the Internet. $149 plus shipping. For more information, E-Mail us at Capcon@shore.net or FAX your order to 508-977-0122.

POCSAG DECODER interface connects to your existing scanner via ear phone jack and your PC. Decodes text and numeric data in real time! Assembled and tested interface with shareware copy of software $49.95 plus shipping. $99.95 for interface and licensed software. For more information, E-Mail us at Capcon@shore.net or FAX your order to 508-977-0122.

REMOTE AB SWITCH
$32.50



This remote control coax switch allows you to switch between two 75 ohm inpututs without leaving the comfort of your chair. Perfect for Mini-Dish satellite systems, video game users, and cable TV households. Requires 2 AA batteries (not included.)

127 THERMOCOUPLES
PELTIER JUNCTIONS

The peltier junction is a solid-state thermovoltaic device. Current applied to the device will produce heat on one side of the device and a cold surface on the other side. Water placed on the surface will freeze or boil depending on polarity of applied voltage. Ideal for applications from 3-12 VDC -- grab a battery and let your imagination run wild! DOCUMENTATION INCLUDED!!!
Small Peltier Junction $20.00
(approximately 1.17"x1.17"x.12")
Large Peltier Junction $29.50
(approximately 1.56"x1.56"x.15")

PHOTON MICROLIGHT

8 Candellas of bright red or yellow light, visible over a mile away! This super-bright LED is secured in a tough ABS case and runs on a 3V lithium battery (included!) It won't burn out because it is an LED! Incredible birght colors! Specify red, yellow, blue or green color when ordering. Battery has a 5 year shelf life and lasts up to 11 hours. (replacement battery $0.98).Great for home or office use, popular with fire and rescue professionals, pyrotechnicians, stage performers, and more.
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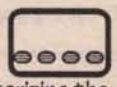
yellow microlight $10.00
blue microlight $15.00
green microlight $15.00

4-NUMBER AUTO DIALER



This four button unit allows you to preprogram telephone numbers (or DTMF codes) for quick dialing convenience. Tone or pulse selectable. Great for emergency numbers like police, fire, and ambulance (color coded buttons make selection simple!) or simply to avoid memorizing the number to call for pizza, the pharmacy, or Aunt Matilda! Ideal for children's phone, elderly, or those with more to do with their time than to remember phone numbers! Approximately 4-1/4"x4-1/4"X1-3/4". Requires 9v battery (Duracell Included!!!)
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A compact on-board camera with the capability to telephoto pan & tilt, zoom, and more...without the mechanical complications of a moving mount! Can be computer controlled throughout the RS-232 port to utilize additional features like fade, exposure, and balance. (User programming is required.) Great quality picture, this camera is ideal for security, stealth surveillance, keeping an eye on the kids, and more. Operates on 12VDC.
Approximate dimensions:
sp = 30mmX25mmX31mm
pc = 58mmX45mmX11mm
wt = 32g
Other useful specs:
exposure: electronic shutter auto iris
signal format: NTSC
lens: F2.4, f=4.7 (horiz. 45 degrees)
resolution: more than 300 TV lines
pixels: 510X492
$350.00
please allow upto 3 weeks for shipment

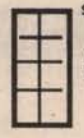
Passive Infra-red Talking Motion Detector !!! $27.50
"Stay out of that refrigerator !", "Watch your step!", "Do your homework", "Don't touch that remote!" ... The possibilities are mind-boggling with this talking motion detector.

You speak into it to record your message (upto 12 seconds long), turn the unit on, and instantly your voice (or your mother-in-laws) reminds anyone in the vicinity that you were expecting them. Message can be changed with the flip of a switch. Uses 4 AA batteries (not included), or an external power source (built-in jack). May be used independently (80 db output) or with an amplified speaker to blast your message throughout the house. Approx 4"x 3-1/2"x 1-1/2".

AMAZING MINI MICRO FM RADIO!
$7.50

Much lighter than a heavy jam box with really good sound! This tiny radio (1.5"x1.06"x0.38") has a seek button, reset control, and an on/off switch. Personal listening has never sounded better! Ideal for ballgames, studyhall, and workouts. Battery and nugget style earphones included.

flexible solar cells!!!



High efficiency flexible solar panels are great for projects! Amorphous silicon alloy on a thin flexible sheet of stainless steel -- now you can make that solar powered T-shirt you've been wishing for...or how about a solar powered RC car? Solar charge your HT battery! The ideas abound!
1.6v @ 350mA $5.95 ea
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approx. 1-3/4" x 6-1/4"

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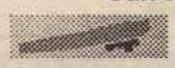
VIRTUAL REALITY COLOR VIDEO HEADSET WITH AUDIO AND MOTION SENSOR $65.00

Watch late night TV without disturbing anyone! This video viewing system can be connected to your vcr and you can watch (and hear) your program on the headset! Of course, it is not like the picture on that 12 foot big screen at the local sports pub, but you can watch in your jammies and see who the guests are on your favorite late night talk show!

Play your favorite video games arcade style! Designed for use with many Super NES and Sega Genesis games, the headset has both audio and motion sensing capabilities. Generally speaking, this is ideal for racing, flight, and tank simulators with a first person or rear view perspective, and games with an eye level perspective.
System features volume control, sensitivity control, brightness control, tint control, as well as a reset button and mode switches to select your application.
Composite video headset system includes headset, tracking tube (for motion sensing), AC adapter, Super NES cable assembly and Sega Genesis cable assembly. A pinout is also included for TV/VCR viewing.

Can't Find Your Remote Control? .....Just Whistle!



You need to change the channel on your TV -- uh oh, the kids are all gone and you can't find the remote control? There's no telling where the kids are, but now you can quickly find your TV, Video, or audio remote. Just whistle and listen for the "beep". The remote-retriever is a small (about 1-1/4"x2") unit you attach to your remote or other easily misplaced device. It comes with its own double-stick tape, and two batteries. It is sensitive (works at a distance of 10-25 feet or more) and unobtrusive -- a really handy gadget! You might also put it on your cordless phone, car keys, or tool box...anything that is never where you want it when you need it! remote retriever $5.95

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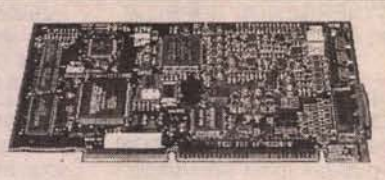

The Ensoniq Soundscape is a 16 Bit Soundcard with 32 Voice Capability. This card is music to your ears.

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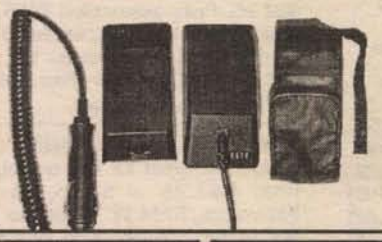

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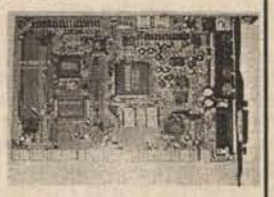
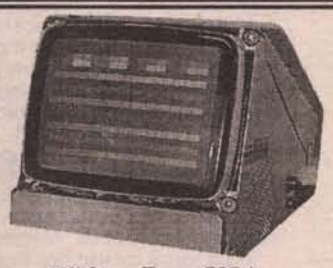


Monitors



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9" Composite "Box" type cabinet. Green screen. Good for **security monitor.** Input for 75Ω (standard) or Highimpedance**$35.00**
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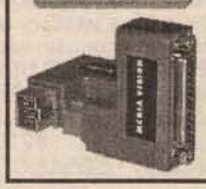

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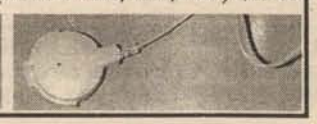

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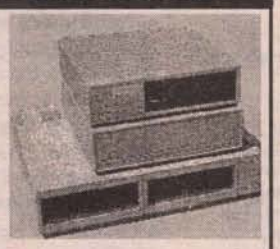

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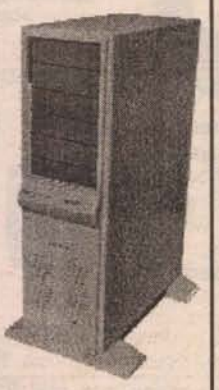

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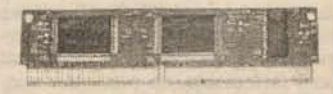

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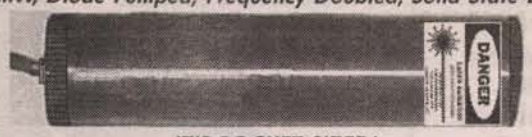

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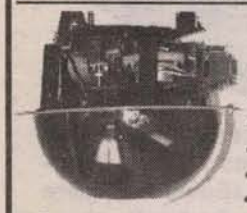

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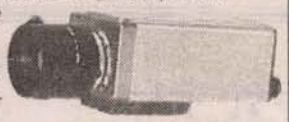

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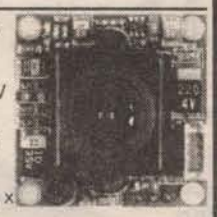

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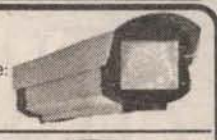

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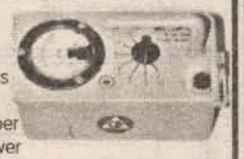

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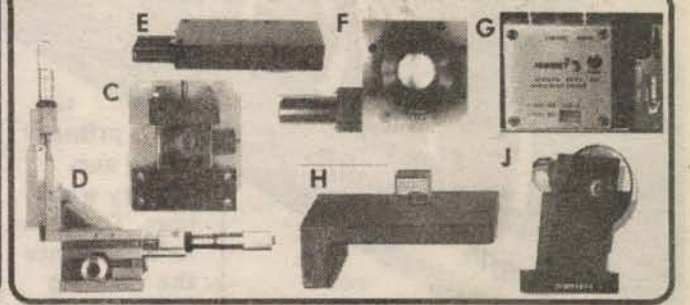

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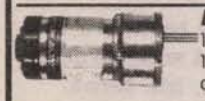

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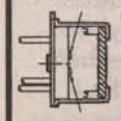

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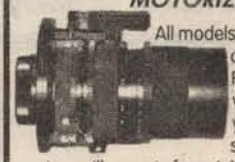

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A TRANSFORMER TUTORIAL

by Frank W. Smith

Much as we learn about ourselves from our mistakes, we can learn a great deal about transformers from their imperfections. Most electronics hobbyists understand the basic principles of ideal transformers; that the winding voltages are directly proportional to turns, currents are inversely proportional to turns, and an impedance connected to one winding is seen from the other winding as being multiplied by the square of the turns ratio. Figure 1 illustrates these fundamentals.

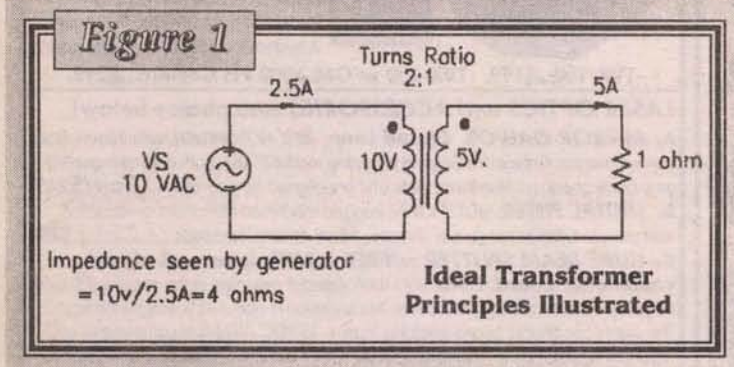


Figure 1 — Ideal Transformer Principles Illustrated

However, all these conditions are only applicable if: (1) all of the magnetic field generated in the any one winding links and induces voltage in other windings; (2) there is negligible resistance in either or all of the windings; (3) there is no hysteresis or eddy current loss in the core; (4) the self-inductance of the excited winding approaches infinity, so that the magnetizing current that produces the flux in the core is near zero; and (5) capacitance effects are negligible.

While many iron core transformers operating at low frequency come remarkably close to meeting some of these criteria, none actually completely meet any of them, and hence never quite live up to the ideal principles stated above. For some purposes it is okay to assume ideal transformers, but for others it is necessary to consider the imperfections of the devices. The equivalent circuit of Figure 2 is helpful in visualizing the transformer's imperfections. In this two winding transformer, Rs represents the combined AC winding resistances of the primary and secondary windings. The term Xs represents the winding "leakage reactance."

In an ideal transformer where every line of magnetic flux generated in the primary winding links the secondary windings and vice versa, flux generated by the load currents would completely cancel in accordance with Lenz's Law, and the core flux would remain constant for all load conditions.

In a real transformer, however, flux linkage is not perfect, and the transformer introduces inductive reactance, usually small, in series with the circuit.

The parallel resistance Rc represents the energy losses due to hysteresis and eddy currents in the core. These are real energy losses and hence can be represented by resistance. The parallel reactance, Xm, is the inductive reactance of the excited winding, and it is the current in this branch that produces the principal magnetic field in the core. The turns ratio is represented by the ideal transformer, the dots showing terminals which have the same instantaneous polarity.

Values for the resistance and reactance components in the equivalent circuit are readily obtained from two simple tests: an open circuit or no load test in which one winding of the transformer is energized at rated voltage with the other winding(s) open; and a short circuit test in which voltage on one winding is applied to achieve rated current with the other winding(s) short-circuited.

In both tests, voltage, current, and power are measured on the energized winding. See Figure 3.

The current in the open circuit test will be quite small, so that the power losses and voltage drops in Rs and Xs are considered negligible, and it is assumed that all power losses are core losses (hysteresis plus eddy current). The core parameters Rc and Xm are calculated as shown in Figure 3a, using applied voltage. The series parameters — Rs and Xs — are calculated in a similar manner from the short circuit test.

In this test, the voltage will be much less than rated voltage, and it is assumed that core losses, which are voltage sensitive, are negligible. While the instrumentation is basically the same as for the open circuit test, it is now the current through the series elements which is known, rather than the voltage across the the parallel core elements. See Figure 3b.

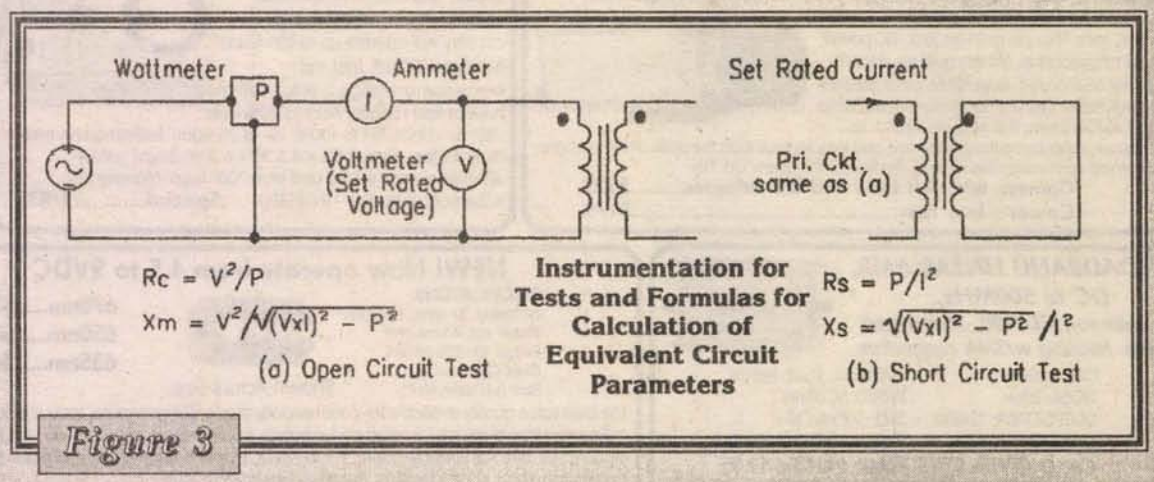


Figure 3 — Instrumentation for Tests and Formulas for Calculation of Equivalent Circuit Parameters

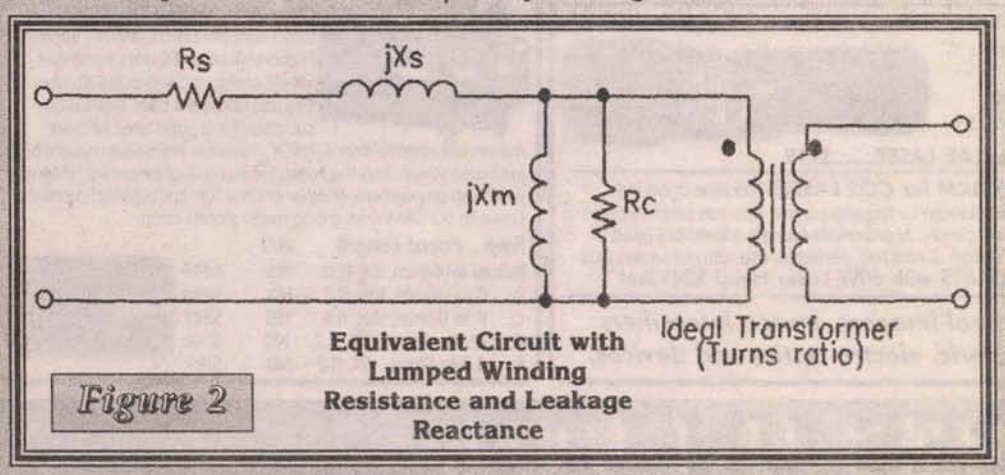


Figure 2 — Equivalent Circuit with Lumped Winding Resistance and Leakage Reactance

While the above tests are normally associated with large power transformers, the same principles should apply reasonably well to small transformers with some loss of accuracy. To make the point, an off-the-shelf transformer rated 120 to 12.6 volts, 1.2 amp, was purchased at a local electronics store and tested with the results shown in Table 1.

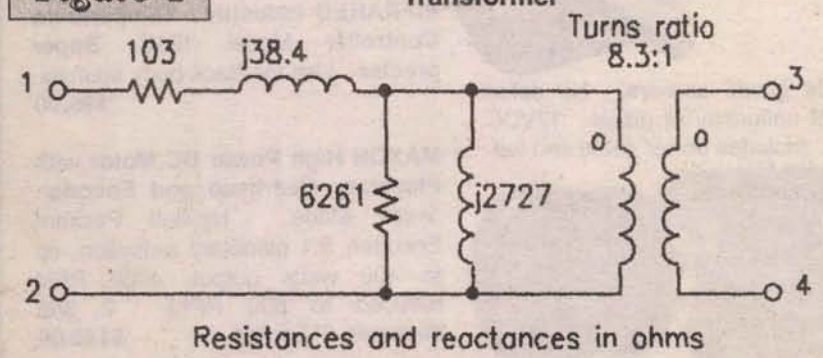
Using the methods described previously, the equivalent circuit shown in Figure 4 was developed.

Table 1 — Test Data on Transformer Rated 120V to 12.6V @ 1.2A, 60Hz

	V1 (volts)	I (amps)	P (watts)	V2 (volts)
Open Circuit Test	120	0.048	2.30	14.4
Short Circuit Test	13.83	0.126	1.63	0

Figure 4

Equivalent Circuit of Tested Transformer



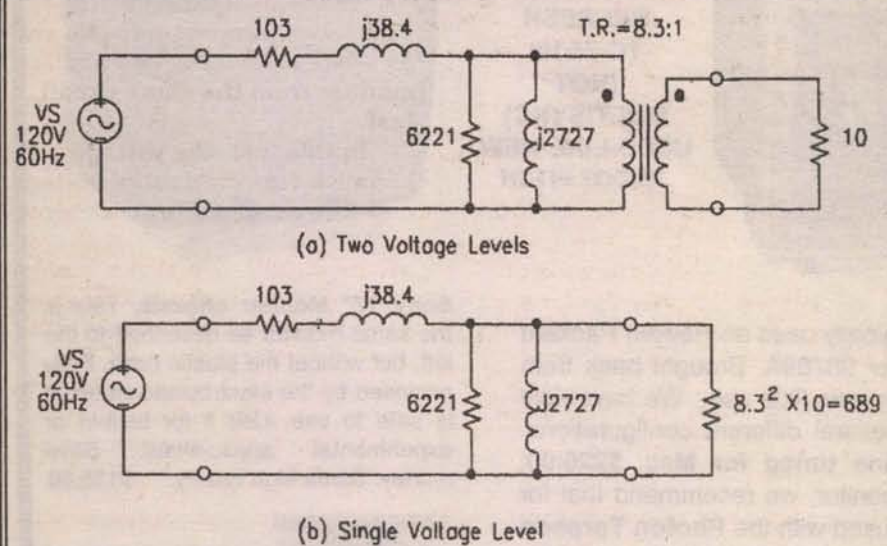


Figure 5 **Equivalent Circuits with 10 Ohm Load**

Figure 6

Equivalent Circuit Referred to Low Voltage Side

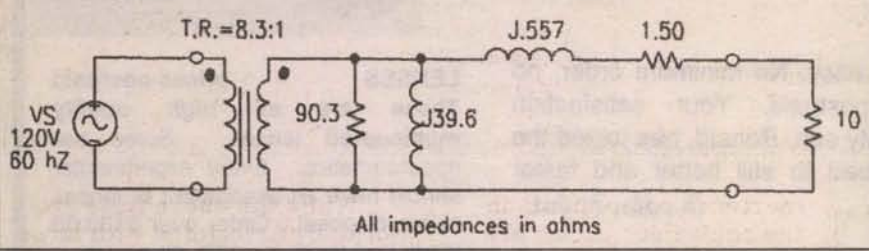
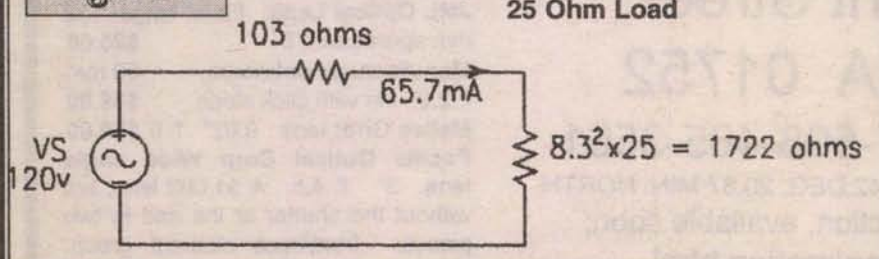


Figure 7

Ultra Simplified Equivalent Circuit with 25 Ohm Load



Impedance transformation is not only an important application of transformers, but enables us to further simplify the equivalent circuit. To understand how impedance transformation works, refer back to Figure 1. By tracing back from the load resistor to the source generator using ideal transformer concepts, it is easy to see that the generator sees an impedance which is a² times the load impedance, where a is the turns ratio, N1/N2.

If we interchanged the source and load, the impedance seen by the source would be divided by a², again with a = N1/N2, to give an apparent resistance of one ohm. One very common application of this principle is in matching the impedance of an amplifier to that of a speaker so as to optimize power transfer in accordance with the maximum power transformer theorem.

We may also use this principle to eliminate the ideal transformer in the transformer equivalent circuit and thus provide for analysis at a single voltage level.

Consider the 120 to 12.6 volt transformer described previously connected to a 120 volt, 60 Hz source and with a resistance load of 10 ohms connected to the 12.6 volt winding.

The complete equivalent circuit, neglecting source impedance, is shown in Figure 5a. The same equivalent circuit with the load resistance referred to the source side is shown in Figure 5b. This was accomplished by simply multiplying the 10-ohm load by (8.3)2.

In many instances, it is more convenient to work from the low-voltage side of the transformer rather than the high-voltage side.

The same principle used to refer the load impedance to the source side in Figure 5 can be used to refer all impedances to the low-voltage side.

To accomplish this, we divide all high side impedances by a². Again, in the example used above, we convert the transformer equivalent circuit to the 12.6 volt side by dividing high side impedances by (8.3)2 and placing the ideal transformer at the high voltage terminals. See Figure 6. (This is the same transformer equivalent circuit that would be obtained if the unit was tested from the low-voltage side.)

Circuit analysis using a complete equivalent circuit as described above can be fairly tedious, and requires skill at complex algebra techniques. Fortunately, for many purposes, including most small transformer applications, substantial simplifications are possible.

While the parallel magnetizing branch components — Rc and Xm — introduce some error in the ideal current transformation ratio, their effects on circuit behavior are often minimal in comparison with the series components — Rs and Xs — and consequently may often be omitted.

This results in a very simple equivalent circuit, consisting of merely a series impedance and an ideal transformer, or, if all parts of the system are referred to a single voltage level as in the preceding paragraphs, of just a series impedance.

Moreover, in small transformers such as that described in this article, the series resistance — Rs — is usually much higher than the leakage reactance, Xs, so that Rs + jXs does not differ greatly from Rs. Thus, Xs for small transformers can often be neglected, which allows us to reduce the equivalent circuit to a mere series resistance.

To illustrate, suppose we wish to find the secondary voltage of the transformer described previously when the load on the full secondary winding is 25 ohms. If we reflect this resistance to the primary side so as to eliminate the turns ratio, we have 8.32x25 = 1722 ohms. Our ultra-simplified equivalent circuit is then as shown in Figure 7.

With 120 volts applied, the primary current is 120/(103+1722) = 66 mA, and the drop across the load — referred to the primary — is .066x1722 = 114 volts. Now, we re-insert the turns ratio, and our secondary voltage is 114/8.3, or 13.7 volts.

We can check the legitimacy of our approximate equivalent circuit by calculating the secondary voltage at full rated load; it should be 12.6 volts.

The full load resistance is 12.6/1.2 = 10.5 ohms, which is 8.32x10.5 = 723 ohms reflected to the primary. The resistance seen from the source is 723+103 = 826 ohms, and the primary current is 120/826 = 0.145 amperes. The load drop referred to the primary is 0.145x723 = 105 volts.

Finally, dividing 105 volts by the turns ratio of 8.3 gives us 12.65 volts, which is very close to the winding rating of 12.6 volts.

A solution using the complete equivalent circuit and complex algebra yielded a load voltage of 12.638 volts. NV

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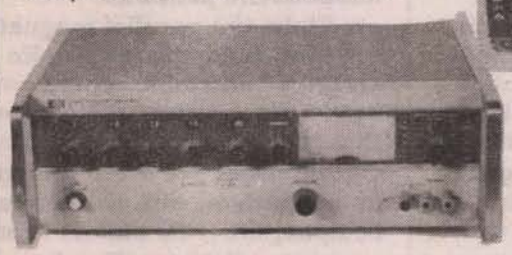

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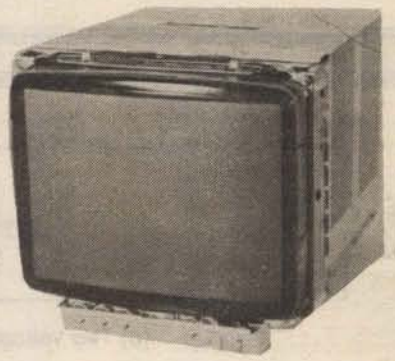

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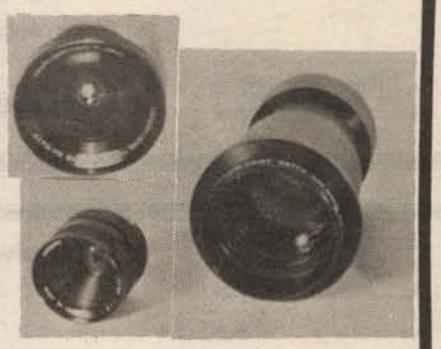

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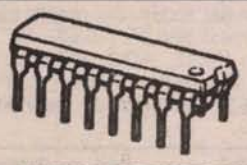

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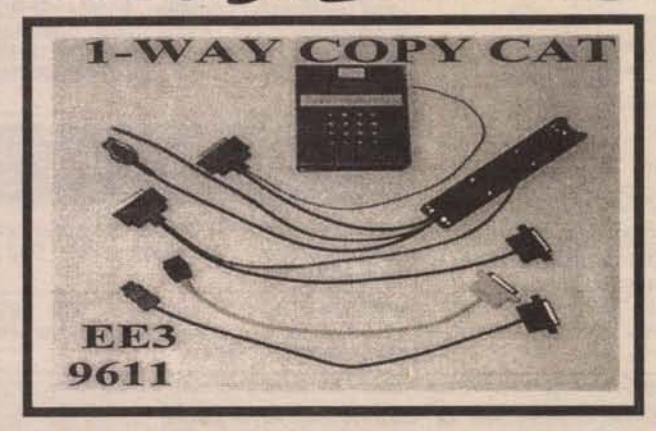

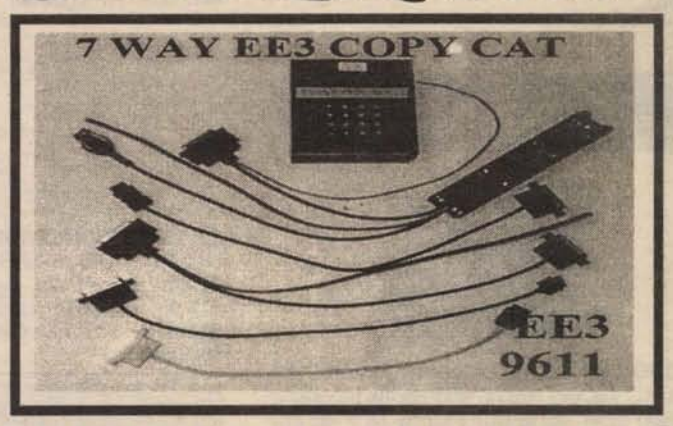

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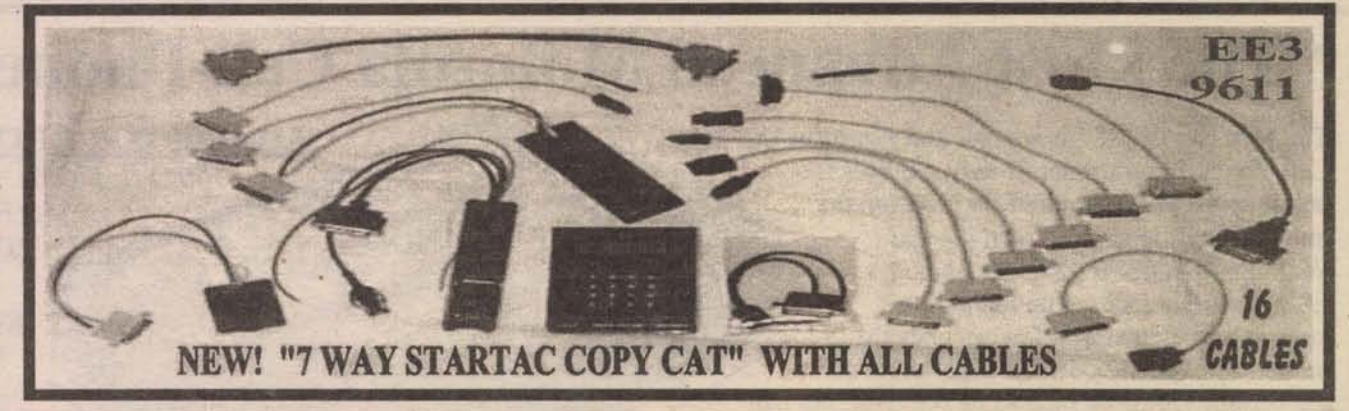

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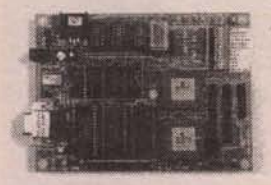

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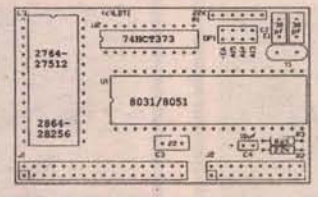

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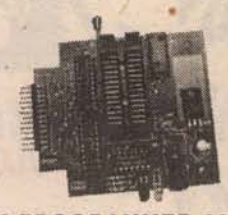

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Welcome to The N&V Solar Workshop ...

A 50-Watt Photovoltaic Installation — Part 2

Bubble, bubble, toil and ... oh, hello there. Just putting the finishing touches on today's extra project. In case you missed last month's episode of The N&V Solar Workshop, we're in the process of building a 50-watt, solar-powered radio shack or experimenter's workbench.

What I'm working on at the moment is a shunt photovoltaic charge controller with a "gas gauge" battery monitor, and low-battery disconnect circuit. But more about that later. The crux of this Workshop is wiring losses and safety. The last thing we want is an electrical fire or battery explosion.

Due to the length of the Workshop this month, the N&V Solar Classroom has been canceled. You can quit cheering, because it'll be back next month. That said, let's step into the Workshop and pick up where we left off last month.

The Workshop

A 50-Watt Solar Installation

Last month, I discussed the sizing of the solar panels and battery array. In case you missed that session, here's a fast recap. The concept is to solar-power a small radio shack. Using worksheets and charts, we determined our load requirements to be about 50 watts. Armed with this information and a solar insolation map, we calculated the battery size at 150 amp hours. A quick look through the solar catalogs produced nine photovoltaic panels suitable for use with our system. You can find a list of these solar modules posted on our Web site **(http://www.nutsvolts.com)** under the name PV-50.TXT.

This month, we're going to wire everything together. Before we do, though, let's take a look at the system (Figure 1). Powering the system is a 50W solar panel, such as Solec's S-55. Next is the Main Control Panel, which contains the circuit breakers, and a Main Power Cut-off switch. Between the Main Control Panel and storage battery array, is a fused Emergency Battery Disconnect switch. Overseeing and controlling this whole shebang is the charge controller (top, Figure 1). Finally, there's the power distribution network, which consists of the power outlets and lighting.

Main Control Panel

Since the Main Control Panel is — as its name implies — the central focus of our solar installation, let's begin there. The Main Control Panel is actually a Square-D breaker box that's been adopted for use with solar power. How does it differ from a regular breaker box, you ask? To answer that question you have to understand the construction of a residential circuit breaker box.

Typically, the breaker box is fed by a 220 VAC line with a neutral wire, which ultimately results in two 110-volt branches that dole out power to your lights and appliances. Basically what we have here are two hot strips separated by a ground (Figure 2). What we're going to do is use this division of forces to separate the power components from the load.

The positive terminal of the battery array connects to one of the hot bars. Attached to this bar is a single, 30A circuit breaker that functions as both a safety device and the Main Power Cut-off switch. One swipe at this switch, and all sources of power are disconnected. To make this happen, though, we have to use a relay to disengage the solar panel.

As you see in Figure 1, the relay is driven off the battery through the Main Power Cut-off circuit breaker. When this breaker is tripped, the relay loses power and the solar panel disconnects. The relay I've selected is an inexpensive automotive relay from Radio Shack (275-226). However, it draws 160 mA of current, which is significant.

A better choice would be a solid-state MOSFET-type relay from Digi-Key, like the D1D20 (Digi-Key part #CC1038-ND) from Crydom.

It draws just 15 mA. Unfortunately, it costs ten times more than the mechanical relay. Whatever your choice, find an out-of-the-way nook for the relay. That's because you'll want access to the fuse more than you will the relay.

If it hasn't caught your attention yet, you'll notice that there's a five-amp fuse inside this breaker box. Don't be tempted to eliminate it or replace it with it with a circuit breaker. It's there to protect against power surges from a close lightening encounter (not a strike) or power surges from a load. Use a UL approved fuse — like an ACG5 — mounted in an appropriate holder.

The other hot bar services the loads, and is fed by the Out+ line of the charge controller. Although I've designed a charge controller for this project which will be presented in a companion article next month, you can use any commercial charge controller that's up to the task, such as the ASC Plus-16 (Figure 3) from Specialty Concepts. The neutral bus, which may run along the side or bottom of the breaker box, serves as the battery negative source. You can earth ground this bus if you wish, but it's not necessary (I didn't). There's a separate earth ground connected to the box that protects us from lightening strikes; more on that in a minute.

As you can see, we're using the circuit breakers for convenient on/off switches that let you shut down individual circuits or the entire system — as well as safety devices. Ah, already I hear the clamor, so let me explain.

I've heard unfounded concerns from PV users who say the 15A circuit breakers aren't protection enough for their sensitive equipment. Listen to me. These are the same breakers you have in your

Figure 3. You can build your own charge controller, or buy a commercial unit, like the ASC Plus-16 from Specialty Concepts, shown below.

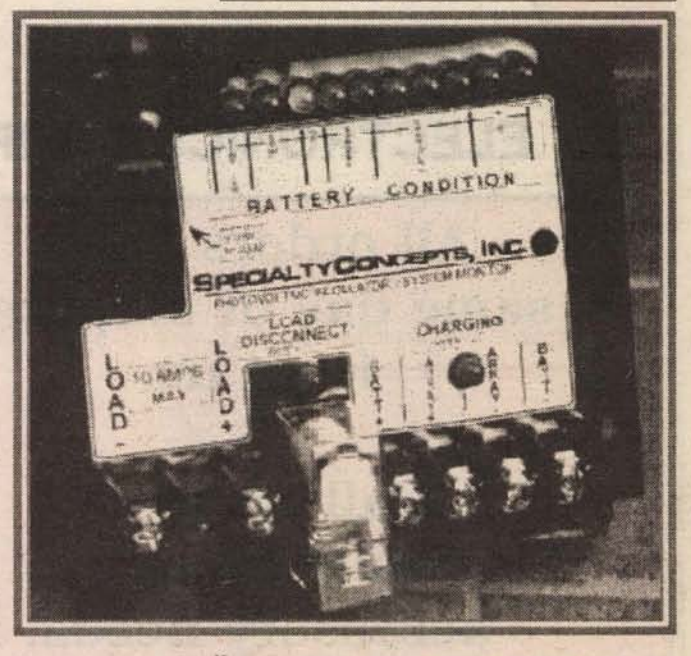
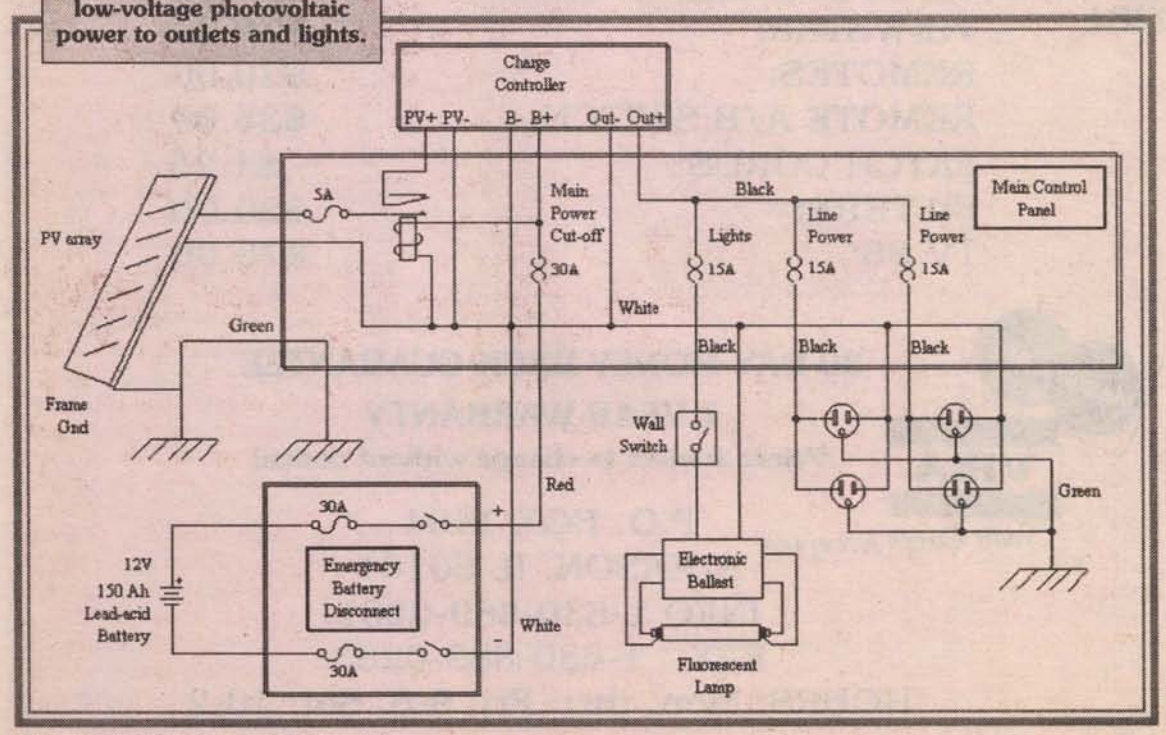


Figure 1. The Nuts & Volts Solar Workshop solar shack provides 50 watts of low-voltage photovoltaic power to outlets and lights.



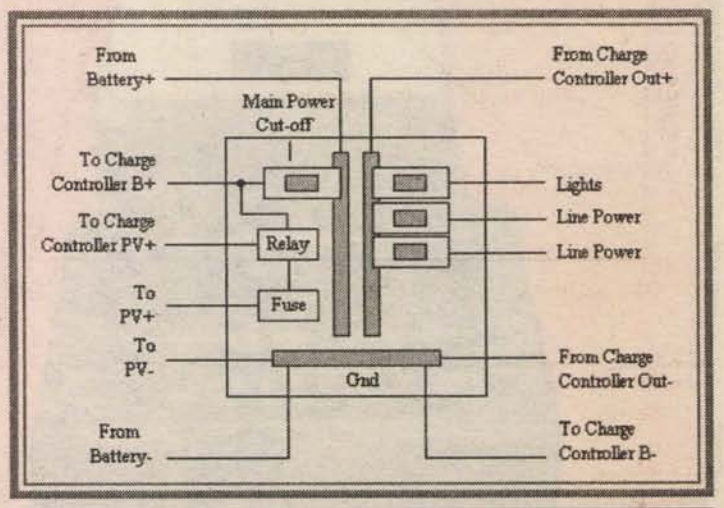


Figure 2. The Main Control Panel serves double duty as a circuit breaker box and control center.

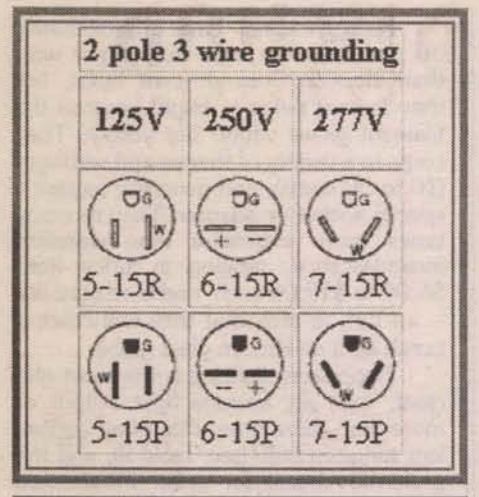


Figure 4. The 6-15P can handle up to 15 amps at 250 volts, and has a unique prong arrangement that can't be mistaken for the 115/220 VAC outlets commonly found in homes and apartments. Pay attention to the polarity, and don't eliminate the ground connection.

Table 1. Just how far away can your photovoltaics or battery be distanced from your rig before it loses its punch? The chart below explains it for copper wire in feet verses wire size. The higher the wire gauge number, the thinner the wire.

Amps	#14	#12	#10	#8	#6	#4	#2	#1/0	#2/0	#4/0
1	45 ft	70 ft	115 ft	180 ft	290 ft	456 ft	720 ft	1160 ft	1440 ft	2120 ft
2	22 ft	35 ft	57 ft	90 ft	145 ft	228 ft	360 ft	580 ft	720 ft	1060 ft
4	10 ft	17 ft	27 ft	45 ft	72 ft	114 ft	180 ft	290 ft	360 ft	580 ft
6	7.5 ft	12 ft	17 ft	30 ft	47 ft	76 ft	120 ft	193 ft	243 ft	380 ft
8	5.5 ft	8.5 ft	11 ft	22 ft	35 ft	57 ft	90 ft	145 ft	180 ft	290 ft
10	4.5 ft	7.0 ft	10 ft	18 ft	28 ft	45 ft	72 ft	115 ft	145 ft	230 ft
15	3.0 ft	4.5 ft	7.0 ft	12 ft	19 ft	30 ft	48 ft	76 ft	96 ft	150 ft
20	2.0 ft	3.5 ft	5.5 ft	9.0 ft	14 ft	22 ft	36 ft	57 ft	72 ft	116 ft
25	1.8 ft	2.8 ft	4.5 ft	7.0 ft	11 ft	18 ft	29 ft	46 ft	58 ft	92 ft
30	—	2.4 ft	3.5 ft	6.0 ft	9.5 ft	15 ft	24 ft	38 ft	48 ft	77 ft
40	—	—	—	3.6 ft	7.0 ft	11 ft	18 ft	29 ft	36 ft	56 ft
50	—	—	—	—	5.5 ft	9.0 ft	14 ft	23 ft	29 ft	46 ft
100	—	—	—	—	—	4.6 ft	7.2 ft	11 ft	14 ft	23 ft

home or apartment, and you don't count on them to keep your TV or Pentium PC from going poof.

The purpose of a circuit breaker is to prevent a fire. It won't protect your keyer or precious QRP transmitter. That's why those devices are fused. With 150 amp-hours behind it, our battery can put out over 450 amps when shorted. Hey, wake up! That's enough current to easily melt a 10-gauge (#10 AWG) wire, and that's what we want the circuit breakers to prevent from happening.

Wiring The Room

Now, I want you to set the breaker box aside and focus on the bigger picture: wiring the room. As any electrician will tell you, this part of the project is critical because a mistake here could ultimately reduce your shack to ashes. So don't substitute #14 AWG wire for #10 AWG wire, or skimp on the quality of the materials.

Basically, we're going to be using the same construction methods an electrician would use in your home to add an outlet for an electric clothes dryer. The materials are the same as he uses, and are readily available at any large hardware store or contractor's supply house.

Electrical Shopping List

Let's first identify the parts we'll need. You've already met the most important component: the Square-D circuit breaker box. For the light switch and outlets, we'll use something called a wiring or wall box. While you can buy these boxes in plastic, I recommend metal. Rigid metal conduit, called EMT (electrical metal tubing), is used to run the wires between the breaker box and wall plugs. (Flexible conduit can be used, too, but it's more costly.)

You'll also need a handful of EMT end connectors. These are small, metal barrels with a thread on one end that screws into the breaker box and wall boxes. Finally, you'll need wire.

The first task is to decide where to locate the Main Control Panel. You'll want it in a convenient, but out-of-the-way, spot. Someplace where you don't have to crawl over workbenches to reach it, yet not where you'll bump into it every time you turn around. Good locations include entry doors, hallways, and utility closets. Often the best spot is on the same wall as the light switch.

Mount the breaker box at the same height as you would a light switch, about 55 inches above the floor. And don't forget to leave room immediately adjacent to the breaker box for the charge controller.

When seeking that perfect location, keep in mind the distances between the breaker box, the battery array, and the outlets. At low voltages, you need to pump a lot more current through the wires for the same wattage than you do at higher voltages. So, the longer the wire is, the more power you lose in the wire itself — which is why you want to keep the breaker box and outlets as close together as possible.

Speaking of outlets, we'll be using a special plug, called the 6-15P (Figure 4), instead of the cigarette lighter connectors often associated with 12-volt power systems. The 6-15P can handle up to 15 amps at 250 volts, and has a unique prong arrangement that can't be mistaken for the 115/220VAC outlets commonly found in homes and apartments.

They are available from local building and electrical suppliers, and most large hardware stores. The 6-15R outlet fits in standard wiring boxes, and uses standard cover plates, even the cute ones you find in the supermarket.

The next step is to determine how many outlets are needed. Like any electrical appliance, each 12-volt instrument sports a plug that needs a receptacle.

For example, you'll need an outlet for the transceiver, one for the linear, and another for a keyer (if you use one). Add to that other miscellaneous items, like a desk lamp or notebook PC, and the numbers add up quickly.

You can fit up to four outlets in a wall box, and more than one wall box can share the same power feed. I wouldn't put more than eight outlets on a single breaker, though. You're better off adding another circuit breaker to the Main Control Panel and running another line if your outlet count runs higher than eight.

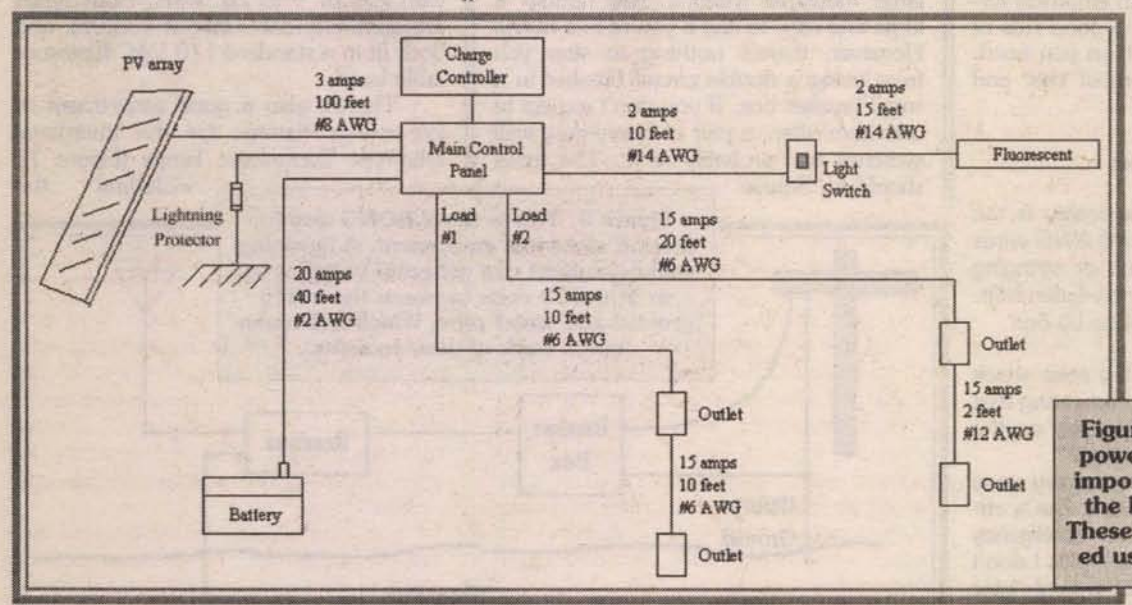


Figure 5. To avoid excessive power loss in the wiring, it's important to pay attention to the length of the wire runs. These wire sizes were calculated using the data in Table 1.

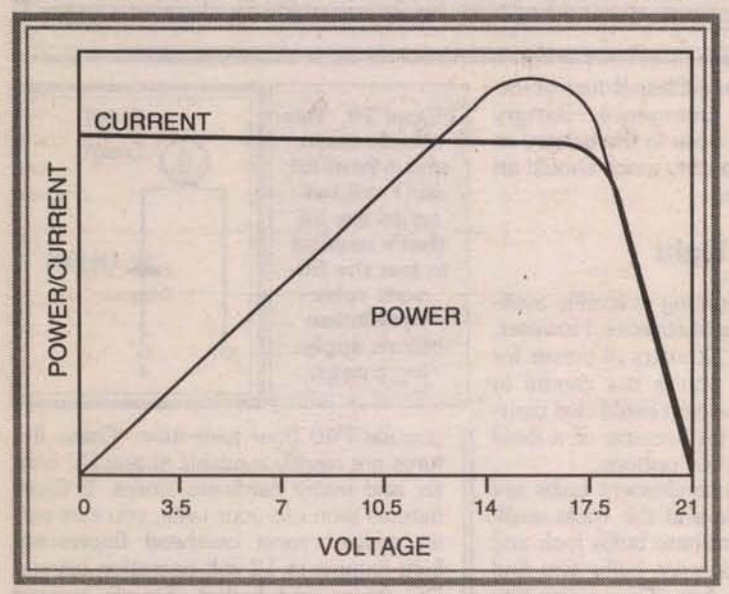


Figure 6. The power of a 12-volt photovoltaic module typically peaks at 16 to 17 volts.

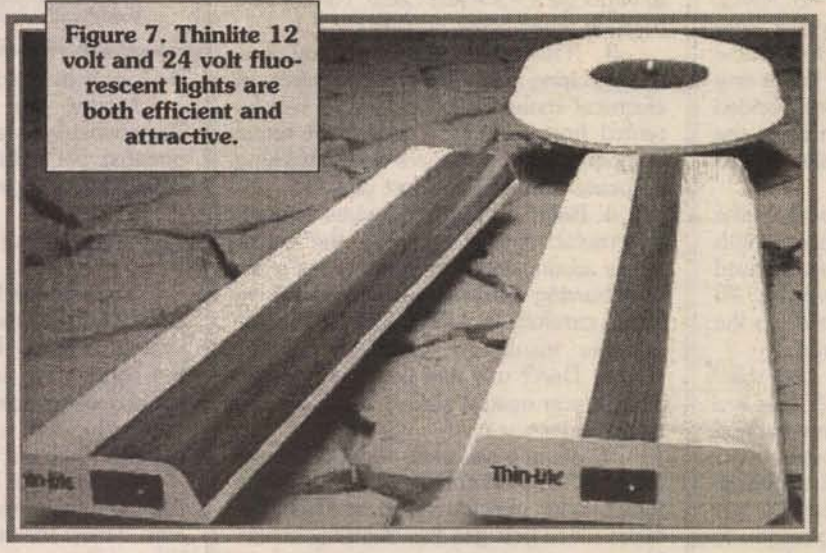


Figure 7. Thinlite 12 volt and 24 volt fluorescent lights are both efficient and attractive.

Where To Buy

Digi-Key
http://www.digikey.com
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Quail Electronics
http://www.quail.com
800-669-8090
power cords & connectors

Specialty Concepts
http:// www.wp.com/SCINC/home.html
818-998-5238
charge controllers

Square-D
http://www.squared.com/index.htm
load centers & electrical supplies

Thinlite
http://www.thinlite.com
805-987-5021
electronic ballast & LV fluorescent

Getting Wired

By now you should have a solid layout in mind. For the sake of argument, let's use the layout sketched in Figure 5 for the next phase, which is calculating the various wire sizes.

Fortunately, most of the math has been done for us in Table 1. This matrix plots current flow against wire length for acceptable power loss. What is acceptable power loss? Two percent. For example, we can readily see from the table that the highest current that 100 feet of #12 AWG wire should carry is less than one amp. Working the other direction, we see that to efficiently move 10 amps of current over a distance of 20 feet, we need to use #8 AWG wire.

Let's look at our layout plan. Notice that the length of the run from the battery is 40 feet, and the maximum current is 20 amps. By cross-referencing these values using Table 1, we conclude that the proper wire size for this run is #2 AWG.

Let's now move our analysis to Load #1, which is limited to 15 amps and feeds four outlets. The first run is 10 feet, so the wire size should be #8 AWG, right? Wrong! When analyzing a wire run, like Load #1, you have to assume that the last outlet on the line is the one drawing the most current. If we decided to go with #8 AWG wire for this run, the wire losses at the last outlet would exceed the two-percent limit.

The correct way to approach the problem is to look at the entire length and calculate accordingly. When viewed in this light, the wire size increases to #6 AWG. The same thinking applies to the light switch and fluorescent lamp.

Are there exceptions to the rule? Always! For example, Load #2. This is a 22-foot run, but you'll notice that the end of the run is only two feet beyond the outlet above it. Again, Table 1 shows us that #6 AWG wire will service this line quite well. However, there's no reason to use #6 AWG wire all the way to the end. For the short two-foot appendage, a hank of #12 AWG wire will do.

Another exception to the rule is the #8 AWG run that connects the photovoltaics. Why did I use undersized wires for the photovoltaics, you ask? Here again you need to look at the bigger picture and use Table 1 as a guide, not a bible.

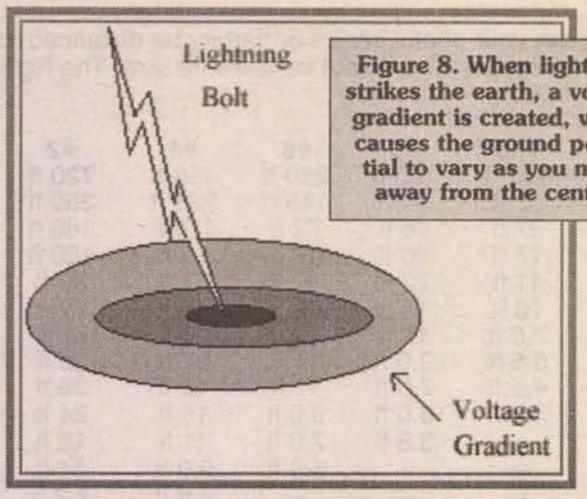

Figure 8. When lightning strikes the earth, a voltage gradient is created, which causes the ground potential to vary as you move away from the center.

Take a look at Figure 6. See how the power curve keeps rising beyond the maximum charge voltage of the lead-acid battery? You've just discovered why many solar panels rate their maximum power at 16 or 17 volts. The loss of a couple volts here is made up for by the higher solar panel voltage.

Would you gain more power if you increased the wire size to recover this power? No. It would only be wasted by the charge controller, so you're money ahead to use the smaller gauge wire.

If you're looking for an empirical formula, there isn't one. But a good rule of thumb is to think bigger than you need, while weighing the factors of cost and practicality.

Use Common Sense

What I mean by practicality is the difficulty of threading two #6 AWG wires through 40 feet of conduit or stringing 100 feet of cable across snow-laden hills. Let's look at these issues one by one.

1. The wiring inside the solar shack has to be protected from overheating that can lead to fire. Don't rely solely on the circuit breakers. EMT is a must.

2. The wiring from the battery array is triple-protected; it's fused; it has a circuit breaker; and there's an Emergency Battery Disconnect switch — plus I don't think a 150 Ah battery has enough juice to vaporize a #2 AWG cable. I'd feel safe running these wires outside EMT.

3. Threading wires of any size through long runs of conduit requires an electrical snake, called a tape. It can be rented from a tool or equipment rental company; let your fingers do the walking to locate the rental nearest you.

4. Before snaking the wires through the metal conduit, remove the sharp edges around the outside lip using a file or deburring tool and pull the wires slowly and carefully to avoid abrading or nicking the insulation which can cause shorts. Don't use petroleum jelly as an aide; if you need a sliding lubricant, use talc powder.

5. When it comes to turning corners with EMT, professional electricians use a tube bender, which you can rent from the same place you got the electrical snake. However, if you only have a corner or two to negotiate, it's easier and cheaper to use what's called a breakout elbow.

6. Make sure the cable from the photovoltaics to the building can be buried or not exposed to direct sunlight. No EMT is needed.

7. Don't count on the EMT for an earth ground. Run a bare #16 AWG copper wire alongside the power wires inside the EMT.

8. Don't try to force a #6 AWG wire into the 6-15R power outlet. Reduce the wire size inside the outlet box using a short piece of #14 AWG wire (commonly called a pigtail) attached to the larger wire with a wire nut.

9. Pay special attention to the outlet's polarity; positive is on the right (Figure 4).

Emergency Battery Disconnect

The next step is to put together an Emergency Battery Disconnect box. It's basically a redundant safety device that disconnects the battery should a problem occur between the battery and Main Control Panel, and is easily assembled. However, a lot of current runs through this box, so you don't want to cut corners here.

The first problem will be finding a suitable on/off switch. I used a fused pull-handle box like the kind used for large industrial motors. The handle is large and easy to find if you're in a hurry. However, there's nothing to stop you from using a double circuit breaker in a small breaker box. If you don't expect to use them often, a pair of heavy-duty wall switches will probably work. The fuses should be Square D Class R placed in a Class R fuse block.

Mount the Emergency Battery Disconnect box as close to the battery as possible, yet within easy reach should an emergency happen.

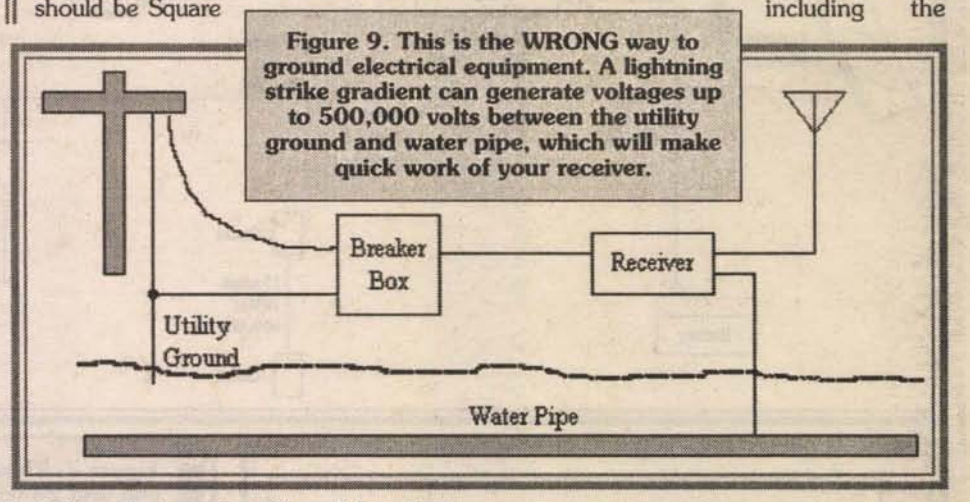

Figure 9. This is the WRONG way to ground electrical equipment. A lightning strike gradient can generate voltages up to 500,000 volts between the utility ground and water pipe, which will make quick work of your receiver.

Let There Be Light

Low-voltage lighting is readily available from a number of sources. However, I've only allocated 22 watts of power for the lighting, so if you're not careful in your lighting choice, you could find yourself in the dark a lot because of a dead battery. Here are your options.

Low-voltage incandescent bulbs are the least expensive and the most available. These medium-base bulbs look and act just the incandescent bulbs you find on supermarket shelves. They screw into standard sockets found in most 110 VAC fixtures, and come in sizes of 15 to 100 watts. The candelabra base versions look like regular nightlight or decorative candle shape bulbs, and require a special socket or adapter. Unfortunately, they're the least efficient type of lighting.

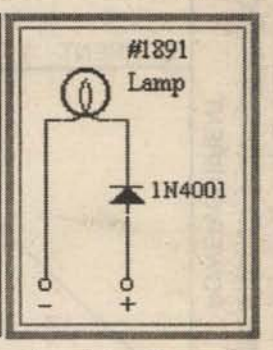

Figure 10. This simple tester and a handful of D cell batteries are all that's needed to test the 50-watt solar installation before applying power.

Halogen lamps have approximately 30 percent more light output per watt than standard incandescent bulbs, but they appear twice as bright because the filament glows white, not yellow. They come in a variety of shapes and wattages (10 to 50 watts), and generally require a special socket or adapter. They're many times more expensive than standard incandescence, ranging in price from $6.00 to $12.00 each, and burn very hot — so hot, in fact, that they will crack a porch light or kitchen glass globe.

Fluorescent lighting is the most efficient, with an average light output of more than three times that of an equivalent tungsten bulb (see Table 2), and the preferred choice for solar. Fluorescent lamps run cool to the touch, they live the longest, and there's a wide variety of size and shapes to chose from.

The easiest fluorescents to install are the circline and D/E tubes. The 22-watt circline fluorescent lamp is a circular tube 9-1/2 inches in diameter that hangs on a ballast with a medium base. While it consumes just 22 watts of energy, it produces the light of a 75 watt bulb.

The D/E tube is a compact fluorescent bulb that plugs into a D/E ballast with a medium base. It comes in wattages of 9 to 26 watts. Both types are quite affordable (about $35.00), and both fit in a standard 110 VAC fixture or table lamp.

There's also a good assortment of low-voltage fixtures for the traditional tube-type fluorescent lamps (Figure 7), including the popular F40 (four feet) tube. These fixtures are readily available at any RV center and many hardware stores. If these fixtures aren't to your taste, you can easily convert most overhead fluorescent light fixtures to 12-volt operation using a DC fluorescent ballast. Simply remove the old ballast transformer and replace it with the low-voltage electronic ballast. They cost about $25.00.

Lightning Protection

Lightning causes millions of dollars

of damage to electrical and electronic equipment each year. Here are a few ways to avoid costly repairs brought on by this phenomenon.

Lightning Basics

The number of times lightning strikes the earth varies depending on the location. In the tropics, many places have 100 to 200 storm-days (the number of days in a year on which thunder is heard at least once) per year. In the US, the number varies from 5 to 90, with a concentration of 3 to 48 lightning strikes per square mile.

Most lightning strikes are harmless. About 30 percent have a peak current of more than 10,000 amps, a current that's easily handled by nearly all lightning protectors. Only 10 percent have a destructive force of over 50,000 amps, a figure that exceeds the rating of most protection devices, and one to two percent have currents in the range of 100,000 to 200,000 amps, with a few strikes exceeding a million amps. The voltage between a thunder cloud and the earth prior to a lightning strike has been estimated from 10 MV to 1,000 MV.

Ground Gradients

The current discharged by a lightning strike is shunted to ground by the protector. However, a local ground connection may not be at ground potential. When lightning strikes the ground, a voltage gradient emanates from the point of the strike (Figure 8), with the potential decreasing as you move away from the center. If you were to stand perpendicular to this gradient, the voltage difference from your left to right foot might kill you, whereas the lucky soul who stands parallel to the gradient would walk away unscathed.

The consequence of this gradient is that any two ground sources entering a building can have very different voltages. Let's consider the circuit in Figure 9, where the power pole is grounded via a stake pounded in the ground, and the radio receiver is grounded via a cold water pipe.

Because the utility ground has less surface than the water pipe, it has a higher impedance, probably on the order of 50 ohms. Now suppose a lightning strike hits the power pole, where it's shunted to ground. This creates a gradient which forms a current path between the water pipe and utility ground.

Ohm's Law tells us that 50 ohms times 10,000 amps is 500,000 volts! You can kiss that receiver good-bye. A better grounding solution is to tie the receiver to the utility ground through the green earth wire.

Preventing Lightning Damage

You can avoid lightning damage to electronic equipment by taking a few simple precautions.

1. Use the right protection device for your application. Metal-oxide varistors, gas discharge tubes, and zener diodes connected across a power line suppress differential transients. Protectors connected from the power line to ground suppress common mode transients. Use transient suppressors that use inductive inductors to help keep common mode transients out of equipment.

2. Put the lightning protectors at the main service entrance, not at the solar panels.

3. Bond services together at a common entrance point.

4. If your equipment has a ground connection, make sure that the ground goes directly to the breaker box and is not daisy-chained through other equipment.

5. Install lightning rods at the solar panel site and building rooftop.

Buttoning It All Up

With the outlet/switch wiring and Main Control Panel in place, it's time to test your wiring skills. Considering the force of our 150 Ah battery, though, it's wise to perform the tests with something less powerful, such as a battery of eight size D flashlight cells in a suitable battery holder. These batteries are inexpensive, and can be used in your flashlight or boom box when you're done.

The test indicator is a simple 1891 flashlight bulb (Radio Shack 272-1112) in series with a 1N4001 diode (Figure 10). With all the breakers turned off, connect the battery pack to the Battery + and Battery- lines of the Main Control Panel. Be sure to observe polarity.

Now turn on the Main Power Cut-off breaker. The LEDs on the charge controller should light; which ones will light depends on the charge controller you installed.

Now turn on the Lights breaker and flip the light switch. The fluorescent lamp should light. Finally, kick on both outlet breakers.

At this point, the system should be fully functional. If the fluorescent light or charge controller LEDs flicker or extinguish, shut down the main power and check your work. If all is well, use the lamp/diode test indicator to verify that each outlet has power of the correct polarity.

The only thing left to do is make sure that the photovoltaic wiring is correct and the relay is working. Shut down the Main Power Cut-off breaker and move the battery pack to the PV+ and PV- lines of the Main Control Panel. Flip the breaker back on, and momentarily short the PV+ line to the Battery+ line to engage the relay. If all is well, the fluorescent lamp will light.

The last chore is to shut off the breakers, connect the solar panel and battery wires, and button up the breaker box.

You're now solar powered. **NV**

Table 2. Comparison of lamp brightness (in lumens).

Watts	Amps	Tungsten	Halogen	Fluorescent
8	0.8	100	130	400
15	1.3	300	390	870
25	2.1	400	520	1450
40	3.4	650	845	3450

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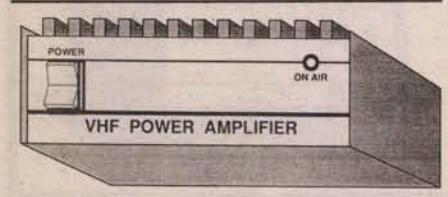

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World's smallest FM transmitter. Size of a sugar cube! Uses SMT (Surface Mount Technology) devices and mini electret condenser microphone, even the battery is included. We give you two complete sets of SMT parts to allow for any errors or mishaps-build it carefully and you've got extra SMT parts to build another! Audio quality and pick-up is unbelievable, transmission range up to 300 feet, tunable to anywhere in standard FM band 88 to108 MHz. 7/8"w x 3/8"h x 3/4"h.

FM-5 Micro FM Wireless Mike Kit.....$19.95

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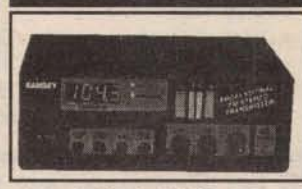

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SS-70AWT, Fully Wired SS-70A with Case.....$79.95
AC12-5, 12 Volt DC Wall Plug Adapter.....$9.95

Tone-Grabber Touch Tone Decoder / Reader

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Super small, high quality fully assembled B & W CCD TV camera the size of an ice cube! Provides excellent pictures in low light (2 lux), or use our IR-1 Infra-Red light source to invisibly illuminate an entire room on a pitch black night! Imagine the possibilities... build it into a smoke detector, wall clock, lamp, book, radio. Exact same camera that's in big buck detective catalogues and stores. Kit includes: fully assembled CCD camera module, connectors, interface PC board kit with proper voltage regulation and filtering, hook-up details, even a mini microphone for sensitive sound! Two models available: Wide Angle Lens 3.6mm/f2, adjustable focus lens, 92 degree view; Pinhole Lens 5.5mm/f4.5, 60 degree view. The Pinhole Lens is physically much flatter and provides even greater depth of focus. The camera itself is 1.2" square. The Wide Angle Lens is about 1" long, Pinhole Lens about 1/2", interface PC board is 1" x 2" and uses RCA jacks for easy hook-up to VCRs, TVs or cable runs. Power required is 9 to 14 VDC @ 150 mA. Resolution: 380 x 350 lines. Instruction manual contains ideas on mounting and disguising the Mini-Peeper along with info on adding one of our TV Transmitter kits (such as the MTV-7 unit below) for wireless transmission!

MP-1, Wide Angle Lens CCD TV Camera Outfit.....$169.95
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MicroStation Synthesized UHF TV Transmitter

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ATV-74WT, Fully Wired 439.25 MHz Converter.....$249.95
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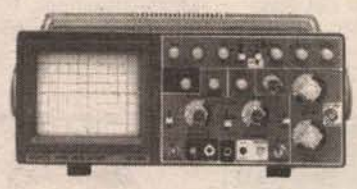

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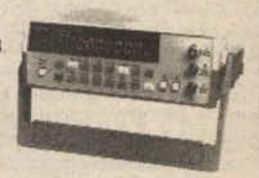

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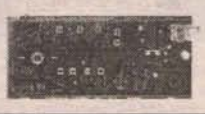

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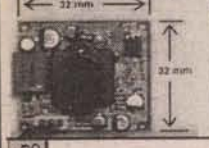

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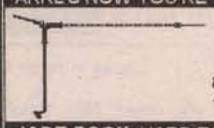

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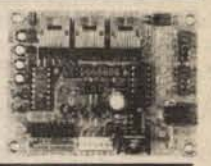

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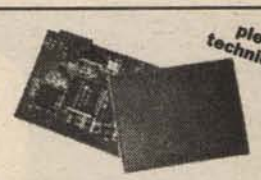

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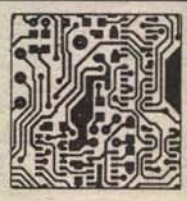

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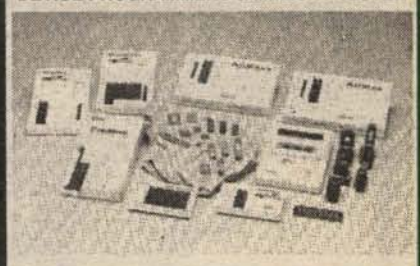

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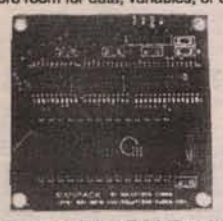

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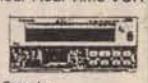

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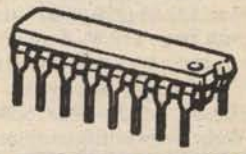

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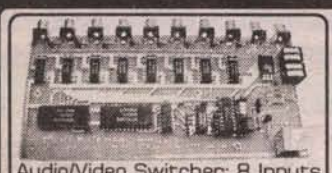

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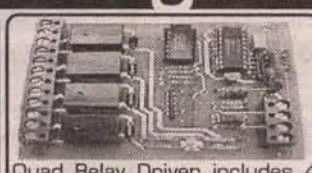

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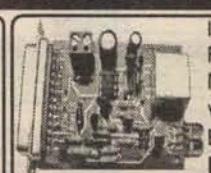

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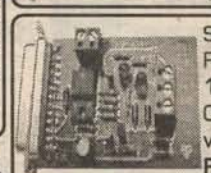

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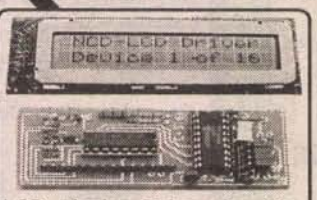

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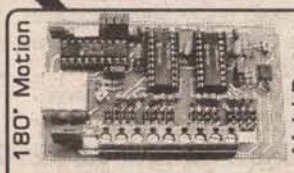

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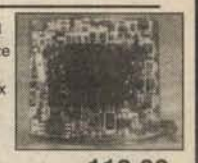

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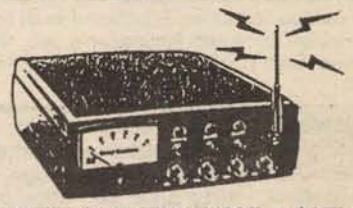

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Don Lancaster's

RESOURCE BIN

number sixty two

A new way to explore trade journals.

Our usual reminder here that the *Resource Bin* is now a two-way column. You can get tech help, consultant referrals, and off-the-wall networking on nearly any electronic, *tinaja questing,* personal publishing, money machine, or computer topic by calling me at **(520) 428-4073** weekdays 8-5 Mountain Standard Time.

I'm now in the process of setting up my new *Guru's Lair* web site you will find at (where else?) *www.tinaja.com*

This is the place you go for instant tech answers. Among the many files in our library, you will find complete reprint sets for all of the *Resource Bin* and other columns.

You will get the best results if you have both *Netscape Gold* and *Acrobat Reader 3.0.* You download these from *www.netscape.com* or *www.adobe.com*

Trade Journals

The key secret to profiting from any tech subject is through the aggressive use of *trade journals.* These are highly specialized and advertiser-paid-for "industry insider" mags stuffed full of reviews, ads, and app notes for useful products. Many also offer seminars, trade shows, free samples, contacts, data books, videos, development kits, and annual directories. Plus various online searching and referral services.

Typically, you can use the free bingo card in the mag to pick up a wide variety of information from a mind-boggling range of sources.

It never ceases to amaze me how often I'll get called by some industry outsider who has "invented" a "new" product, yet never heard of the key trade journals in their target field.

More often than not, reading a few decades-old trade journals will show them why their great "new" idea was fatally flawed. Or why there are full page ads already selling it.

More on this can be found in my *Case Against Patents* package. And in WHEN2PAT.PDF on *www.tinaja.com*

The better electronic trade journals are *E.E. Times, EDN,* and *Electronic Design.* Plus *Electronic Products* or the *Electronic Component News.*

Your finest two mechanical design titles are *Machine Design* and *Design News* aided by *New Equipment Digest.* We saw a lot more on these in my file RESBN08.PDF on *www.tinaja.com*

Getting Trade Journal Literate

Your best method to find out about trade journals used to be the *Ulrich's Periodicals Dictionary* as found on the reference shelf of your nearby library. Along with its quarterly updates and their *International Standard Periodicals* competitor. Detailed are some 85,000 trade journals, many of them free.

Ulrich's remains the best for those more obscure mags from smaller and lesser known pub houses.

A third reference publication called *Standard Rates & Data* also gives you hints of who is publishing what. This one mostly gives you the advertising rates for various magazines.

A fourth method to find the really strange low-end publications of every shade and interest is Seth Friedman's *FactSheet Five.* They definitely do have something here to offend everyone.

Other ways to hit on trade journals are to visit larger technical libraries, especially their *public serials lists.* Plus *always* keeping your eyes open any time you are in the waiting room or reference area of most any company or industrial site.

Your final route can be automatic and free. Once you subscribe to most any trade journal in a field, the others will climb all over each other trying to get you to subscribe to theirs.

My "New" Method

Sadly, Ulrich's is not available free on the net. At least not yet. As far as I know, you still have to go to *Dialog* or another pricey fee-based service to gain access. The printed versions are not able to give you powerful "any word" searching, besides their being months to years out of date.

There's now a "new," obvious, and completely net-friendly way to pick up most trade journals. It seems that typical trade journal publishers print dozens or even hundreds of different titles. Economics of scale and such. So, you just hit on the higher profile publisher's web sites to find most of the magazines in a big hurry.

The advantages of this method are that you will find most mags quickly and conveniently. New mags also are fast to appear. Even having their own fully searchable web sites. Often, you can instantly get a sample copy.

Your downside is that all the really superb trade journals are often those obscure labor-of-love pubs who still care about their readers. Thus, you're almost certain to miss these goodies if you only target the giants.

Let's take a random tour of some of the major trade journal publishers to see just what they have to offer ...

Miller Freeman

For sheer number of titles in print, these folks are hard to beat. Check out their web site at *w3t.mfi.com* — the best we've got room for is a sampler.

Their electronic and computer titles do include *Computer Security Journal, Game Developer, Digital Video, DSP World, Keyboard, Mathematica Journal, Music and Computers, Printed Circuit Design, Pro Sound News, Studio Sound, Videography, Web Techniques,* and *Web Design & Development.*

The full *Miller Freeman* list is utterly unbelievable. Such as: *Alt.Office, Surf Business, Cabinet Maker, Architectural Lighting, Bass Player, Bicycle Retailer, Contract Design, Embroidery Monogram Business, Health and Fitness Business, Impressions* (a superb T-shirt printing mag), *Leather Times, Pig Farming, Pulp and Paper, Tunnels and Tunnelling,* and *Wood Technology.*

So, if you are ever going to go and embroider bicycle riding musical pigs underground, you'll be all set.

Cahners

Cahners publishes some really cheezy mags. Such as *Dairy Foods* and *Cheese Market News.*

Outside of these, they do produce an amazing variety of higher quality trade journals covering an even more astounding breadth of topics.

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mechanical engineering title. The electronic titles include *EDN, Electronic News, Wireless Design and Development,* and *Test and Measurement World*

A sampling of their other offerings: *Cabinet Maker, Scan Tech News, Library Journal, Security,* that *Fiberoptic Product News,* the *Library Journal, Graphic Arts Monthly, Powder and Bulk Solids,* and *Upholstery Design.*

IDG

IDG claims that they are the largest publisher of international technical magazines. I like their *InfoWorld* best. But Cringely sure has gone downhill lately. Some other titles here: *Publish, ComputerWorld, Webmaster, The Web,* plus their newsstand *PC World* and *MacWorld.*

CMP

If you were only to subscribe to one electronic magazine, go for *E.E. Times. CMP* publishes lots of trade journals and newsstand magazines. A few of the former include *Electronic Buyer's News, OEM, Computer Reseller,* and *Communications Week.*

And their newsstand offerings now include *Windows Magazine, Home PC,* and *Net Guide.*

Penton

Penton publishes everything from *Air Transport World* to *Welding Design & Fabrication.* Their *Machine Design* is the best mechanical design magazine. And their *New Equipment Digest* is real heavy on free product samples.

A few electronic titles are *Electronic Design* (great *Bob Pease* column), *E.E. Product News, Microwaves and RF,* and *Wireless System Design.*

Chilton

Most of you know *Chilton* for their auto repair books and manuals. But they also have some four dozen trade journals they publish.

Electronic offerings are *Electronic Component News, Wireless Week,* and their highly useful *Electronic Industry Telephone Book.*

EITD is the second most significant resource for our tech helpline, after my *Names & Numbers* directory.

Other Chilton pubs you may find of interest are *Video Business, Automotive Industries,* the *Multichannel News,* and *Video Software.*

PennWell

My favorite PennWell publication is *Fire Engineering.* But they sure have a wide range of industrial titles.

For instance, if you are doing light and optics, check out *Lightwave, Laser Focus World,* or *Industrial Laser Review.*

To see their information technology stuff, look at *Digital Magic, Electronic Publishing, Computer Graphics World, Color Publishing, Computer Artist,* and *Back Office.*

I don't know what that last one is about, but I just sent for a copy.

Several other interesting PennWell titles are *Computer Design, Solid State Technology,* and *Power Engineering.*

Hearst Business Publishing

Hearst is probably your single most important electronics publisher. The parent company also does bunches of newsstand magazines such as *Popular Mechanics.* And insider mags for floor coverings, electronics, and autos.

Their *Electronic Products* is a good second tier trade journal. They also publish their *IC Master.* Which is *the* crucial directory to integrated circuits worldwide. And their *EEM Master,* a directory of everything else electronic.

Plus regional supplier versions.

Story Communications

A Texas outfit which specializes in weekly all-ads technical shoppers. For surplus, distress, aftermarket, and repair. Titles here include *Print-Mart, Compu-Mart, Compu-Mgr,* and a pair of telephone systems titles called *The Mart* and *Tele-Mgr.*

Asian Sources

These folks distribute a number of far east publications in the US. All of them being mostly wall-to-wall ads for zillions of offshore suppliers.

Titles you might be most interested in are *Electronics* (whole systems such as VCRs TVs, and radios), *Electronic Components* (bits and pieces), *Telecom, Computer Products, Security,* and their brand new *Video and Multimedia.*

Unrelated titles include the ineptly misnamed *Hardwares* on the hardware store stuff, *Fashion Accessories, Gifts & Home Products, Timepieces,* and *Fabrics & Manufacturing.*

Asian Sources also provides product locator services and directories. Sadly, their typical subscriptions do average $70.00 each. Er, double that for prompt delivery. Typical issues will have a coupon good for one free sample of any other title in the series. So, if you can find *anybody* that has a sub, chances are you could use their coupons to sample titles of interest.

Helmers Publishing

This is a small labor-of-love set-up from Carl Helmers, a former editor of *Byte* magazine. His four rather well done publications include *ID Systems, Sensors, Desktop Engineering,* and *SETI Quest* on alien eavesdropping.

Ziff Davis

At one time, Ziff had bunches of trade journals. They have sold many of these and now largely concentrate on mass-marketed newsstand mags. *PC Magazine* and *Computer Gaming* are typical. Remaining trade titles include *MacWeek* and *Inter@ctive Week.*

And a few others.

Some Also Rans

North American Publishing is big on media, broadcasting, retailing, direct marketing, printing, publishing, and packaging. Titles of interest here may include *Magazine & Bookseller, Target Marketing, Printing Impressions,* and *In-Plant Graphics.*

Measurements & Data now have four pubs. These do include *Measurement & Control* and the *Measurement & Control News* magazines. The former includes additional tutorial material, while the latter is free. They also publish *Medical Electronic Products* and their *Medical Equipment Designer.*

IMAS is your home for *Radio World, TV Technology, Tuned In,* the *Pro Audio Review,* and *Computer Video.*

CurtCo Freedom publishes an *Audio Video Shopper, Mobile Computing Home Theater, Entertainment at Home, Mobile Sound,* and *Flightalk.*

ISC publishes chem lab stuff. Such as the *American Laboratory, American Biotechnology Laboratory,* the *American Clinical Laboratory,* and their *American Environmental Laboratory.*

Cardinal prints *ENT, HP Professional, Internetworking, Digital Age, Electronic Publishing, Imaging World, Electronic Musician, MIX,* and *Unisphere.* They also operate the direct mail and online *MIX Bookshelf.* Which is the definitive source for audio and video titles.

Horizon House is your location for *Microwave Journal, Telecommunications,* plus a military electronics magazine. Besides being a printer of specialty filter and communications books.

Advanstar has a broad base of

trade journal magazines. Several you might find of interest here are *Automatic ID News, GPS World, PC Graphics, Video Store, CADalyst, Response TV, Voice+,* and *Medical Device Technology.*

This Month's Contest

I can't believe how many of these major big time publishers have buried their address and telephone numbers some thirteen screens deep into their web site. The first things that *any* web site visitor wants to know are "Where are you?" and "How can I reach you?"

I did not even mention "place your name, address, and phone number on your home page" in our previous web secrets columns, because I felt that nobody, but nobody, could possibly be that stupid.

I was wrong.

At any rate, I've placed annotated links to scads of useful trade journals and many of these publishers on my *www.tinaja.com* web site. Also see my file RESBN62.PDF.

For our three contests this month, just tell me about any unusual trade journal or trade journal publisher that I do not already know about. Or else tell me where I could pick up free and convenient searchable *Ulrichs* access on or off the net. Or tell me about a big time stupid mistake that any big time webmaster made.

There will be a largish pile of my new *Incredible Secret Money Machine II* books going to the dozen or so better entries, plus an all-expense-paid (FOB Thatcher, AZ) *tinaja quest* for two that will go to the very best of all.

Send all your *written* entries to me here at *Synergetics,* rather than to *Nuts & Volts* editorial. **NV**

Microcomputer pioneer and guru Don Lancaster is the author of 33 books and countless tech articles. Don maintains his no-charge US tech helpline found at ***(520) 428-4073****, besides offering all of his own books, reprints, and consulting services. Don also offers a free catalog full of his resource secrets waiting for you. Your best calling times are 8-5 on weekdays, Mountain Standard Time.*

Don is in the process of setting up his Guru's Lair at http://www.tinaja.com

Full reprints and preprints of all Don's columns and ongoing tech support appear here. You can reach Don at Synergetics, Box 809, Thatcher, AZ 85552. Or send any messages to his US Internet address of ***don@tinaja.com***

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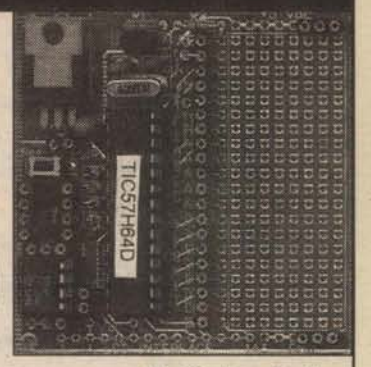

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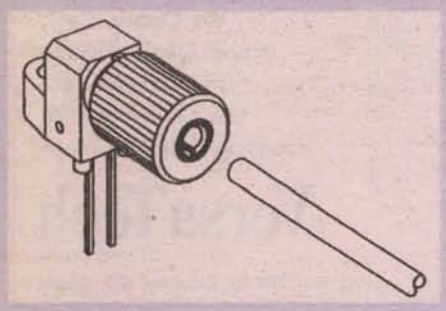
FIBER OPTIC COMPONENTS



Industrial Fiber Optics announces a new line of high-quality, low-cost fiber optic components for use with plastic optical fiber. Applications include electronic games, household appliances, audio systems, optical networks, automotive electronics, and medical instruments.

The new line consists of two LED performance levels and five photodetectors: photodiode, phototransistor, photodarlington, and two photoschmitts. All mate easily with standard 1 mm (1,000 micron) fiber with a 2.2 mm OD jacket.

Cost-per-unit ranges from $1.60 to $4.73.

For more information, contact:

INDUSTRIAL FIBER OPTICS
P.O. BOX 3576, DEPT. NV
SCOTTSDALE, AZ 85271
602-804-1227 FAX: 602-804-1229

WSS-100 WIRELESS SURVEILLANCE SYSTEM

The WSS-100 Wireless Surveillance System is the solution for the person or business that would like to have their eyes and ears in two places at once.

This ordinary looking clock/radio incorporates a high-resolution black and white camera (410 TV line resolution), and FCC approved transmitter that delivers consistently sharp video images with audio to its designated receiver. In addition, the use of state-of-the-art circular polarized directional transmitting and receiving antennas maximizes the signal range and minimizes interference from unwanted signals. Capable of penetrating through walls and floors, the WSS-100 has an effective range of up to 300 feet.

The WSS-100 comes complete with clock/radio, four-channel receiver, audio/video cable, one A/B switch, one coaxial cable, one power adapter, and lastly, the instructions.

The special introductory price for this Complete Wireless Surveillance System is $649.95.

For more information, contact:

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914-735-6127 FAX: 914-735-3560
HTTP://WWW.SPYSITE.COM

VIDEO PACKER PRO™

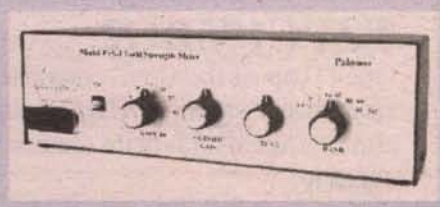
The Video Packer Pro™ system available from VIC Hi-Tech Corporation, provides PC users breakthrough connectivity for their visual conferencing calls. Using a normal phone line, users can dial up and connect with any other PC equipped with H.324 compatible videoconferencing software and hardware. The connection is made even when callers are using different television standards — whether they happen to be PAL, SECAM, or NTSC.

The Video Packer Pro add-on card assures clear, lifelike motion, and 30 frames-per-second transmission speeds. Bundled in a computer system with a 133 MHz PC equipped with SVGA card, 28.8 Kbps modem and monitor, the card and system sells for a suggested retail price of $3,995.00.

For more information, contact:

VIC HI-TECH CORP.
2221 ROSECRANS AVE. STE. 237
DEPT. NV
EL SEGUNDO, CA 90245
310-643-5193
http://www.vic-corp.com

PFS-1 FIELD STRENGTH METER



Palomar Engineers announces a new field strength meter, Model PFS-1. It has features needed for serious antenna work: A detector linear over nearly a 30 dB range, an accurate step attenuator with 30 dB range, a 25 dB RF amplifier, high Q tuned circuits to suppress out-of-band local signals, and a panel meter readable to .1 dB.

The meter covers 1.8 to 150 MHz and is powered by 9 or 12 volt batteries. Antenna connection is a SO-239 jack on the rear of the aluminum cabinet. Model PFS-1 is priced at $195.00.

For further information, contact:

PALOMAR ENGINEERS
P.O. BOX 462222, DEPT. NV
ESCONDIDO, CA 92046
619-747-3343 FAX: 619-747-3346
E-MAIL:
75353.2175@compuserve.com

ULTRASONIC LOOP CONTROLLER

The SONA-TROL® PW mini series features a compact sensor head that measures only 3" x 3" x 2-1/4" and senses strips down to .010", rejects false signals, and is unaffected by dust, dampness, and variations in line voltage. Easily integrated into any loop and drive system, it includes a power supply and control electronics in two DIN rail mountable modules, or an oil tight JIC enclosure.

SONA-TROL PW mini series ultrasonic loop controller systems are priced from $250.00 (list).

For more information, contact:

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25 WEBB ST., DEPT. NV
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401-781-3904 FAX: 401-781-1650

MODEL 8700 PULSE COUNTER

Electronic Control Concepts announces the availability of a new product. The Model 8700 x-ray pulse counter and exposure time meter is used to measure x-ray exposure time. The instrument can measure the duration of radiation output produced by both AC or DC x-rays. This allows the measurement of exposure time for a wide variety of medical and dental x-rays. A sensitive x-ray detector inside the 8700 allows direct measurement of the length of exposure.

The Model 8700 pulse counter is a small, handheld instrument that uses a standard nine-volt battery.

The Model 8700 can be ordered directly from Electronic Control Concepts for $395.00. An optional remote sensor (8700RS) is available for $50.00 when ordered with the 8700. The remote sensor option allows the 8700 to be placed up to three meters from the x-ray source being tested.

For more information, contact:

ELECTRONIC CONTROL CONCEPTS
213 CHAS. HOMMEL RD.
DEPT. NV
SAUGERTIES, NY 12477
1-800-VIP-XRAY
FAX: 914-247-9028
E-MAIL: eccxray@mhv.net

PROGRAMMABLE SOLDERING STATION

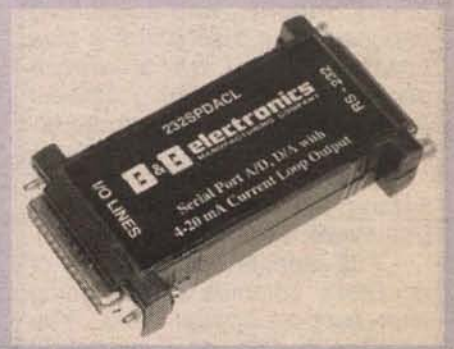
The Antex Model 690SD soldering station offers temperature control from 65°C to 450°C with 2°C repeatability and two pushbutton memory settings. Featuring a 24-volt, 50-watt static-dissipative soldering iron that provides positive tip temperature feedback, it includes a separate bench stand with a dross collection sponge.

The Antex Model 690SD soldering station sells for $346.45 (list).

For more information, contact:

M.M. NEWMAN CORPORATION
24 TIOGA WAY
P.O. BOX 615, DEPT. NV
MARBLEHEAD, MA 01945
617-631-7100 FAX: 617-631-8887

SPDA MODULES



B&B Electronics announces the 232SPDA and 485SPDA modules, simple serial port data acquisition modules that interface seven

New Products

A/D channels, two digital inputs, one digital output, and four D/A channels to an RS-232 or RS-485 port. These modules allow your PC to read and output analog voltages, as well as monitor and set digital I/O lines. In addition to these features, the 232SPDACL and 485SPDACL units can output a 4-20 mA current which is useful when long wire runs with analog signal are required. RS-485 connections are made using terminal blocks while RS-232 and I/O connections are made through DB-25S (female) connectors. Applications include: monitoring various sensors, controlling process and test equipment, and monitoring and controlling ON/OFF states.

Prices $89.95 for the 232SPDA and 485SPDA; and $99.95 for the 232SPDACL and 485SPDACL.

For more information, contact:

B&B ELECTRONICS MANUFACTURING CO.
707 DAYTON RD.
P.O. BOX 1040, DEPT. NV
OTTAWA, IL 61350
815-433-5100 FAX: 815-434-7094
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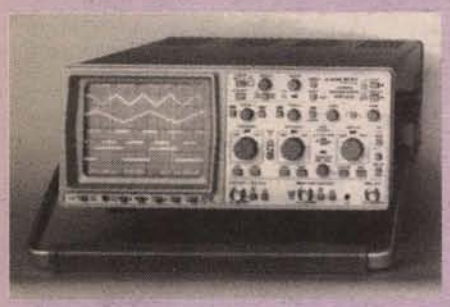

Hameg introduces the HM1004 and HM1505 multi-function oscilloscopes. These microprocessor-controlled oscilloscopes have been designed for a wide multitude of applications in service and industry. Ten different user-defined instrument settings can be saved and recalled without restriction. The built-in RS-232 serial interface allows for remote controlled operation via PC.

Features of the HM1004 and HM1505 include two vertical input channels, and the second time base with the ability to magnify — over 1,000 times — extremely small portions of the input signal. The second time base has its own triggering controls, including level and slope selection, to allow a stable and precisely referenced display of asynchronous or jittery signal segments.

The trigger circuit is designed to provide reliable triggering to over 250 MHz at signal levels as low as 0.5 div. An active TV sync separator for TV-signal tracing ensures accurate triggering even with noisy signals. Signals are solid and distortion-free even at the upper frequency limit. The built-in Y delay-line allows for leading edge display of even low repetition rate signals, supported by the 14 KV CRT with its high intensity.

For more information, contact:

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516-794-4080 FAX: 516-794-1855
1-800-247-1241
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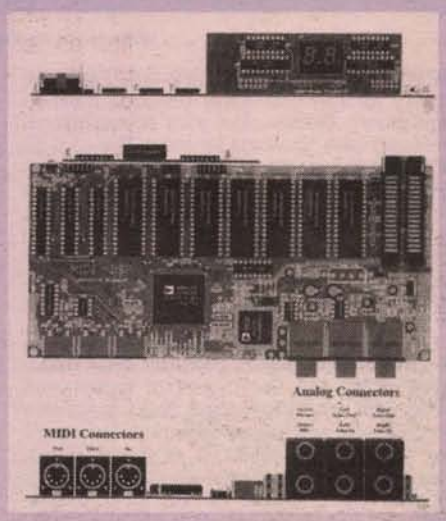
MIDI-DSP DEVELOPMENT SYSTEM



Cyberphonic Research's MIDI-DSP development system is for developers interested in creating digital signal processor (DSP) equipped audio devices which are computer programmable and interactive.

The system consists of a hardware platform (MIDI-DSP board and power supply), and development software (Assembler, Linker, PROM Splitter, Demonstration Programs, MIDI-DSP Board Monitor, and MIDI-DSP Loader).

MIDI-DSP development system is $695.00 US.

For more information, contact:

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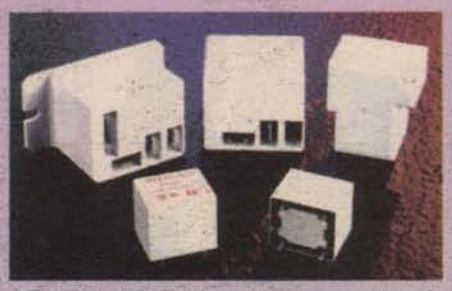
ELECTROMECHANICAL RELAYS



GEM NT-Series electromechanical relays feature the model NT73 which is a sealed PCB mountable device available with 1-Form-A, 1-Form-B, and 1-Form-C contacts. Measuring 19.5 mm L x 16.5 mm W x 16.5 mm H, it is rated at 3 to 12 amps @ 28 VDC or 120 VAC.

The GEM NT-Series also includes the model NT90, a 30-amp @ 120 VAC or 15 amp @ 240 VAC relay offered in a PCB mount version or with a PC board mount coil and terminal contacts, or as an all terminal full panel mount device. All relays are UL/CSA approved.

For more information, contact:

GEM ELECTRONICS, INC.
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The first member of each microcontroller family — the PIC16C642 and PIC16C662 — offer 4.0-volt brown-out protection, two high-precision voltage comparators, and a voltage reference module to support low-cost systems requiring analog interface capability. These features improve system integration, increase reliability, lower manufacturing costs, and reduce board space and component count.

For more information, contact:

MICROCHIP TECHNOLOGY, INC.
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DEPT. NV
CHANDLER, AZ 85224-6199
602-786-7200 FAX: 602-899-9210

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Logical Devices, Inc. announces the new device programmer, the XPRO LC. The XPRO LC is a cost-effective, high-quality, industrial grade device programmer that is user-configurable to most any desired application.

The XPRO LC features an intuitive Windows software interface with serial port connection to any PC compatible host. Interchangeable hardware modules have been developed for the XPRO LC base which allow it to support both generic (EE/EPROM single or gang in DIP and PLCC) and device-specific applications.

The XPRO LC base unit price is $495.00. Module prices start at $99.00. The base unit measures 5" x 11" x 3" and weighs three pounds.

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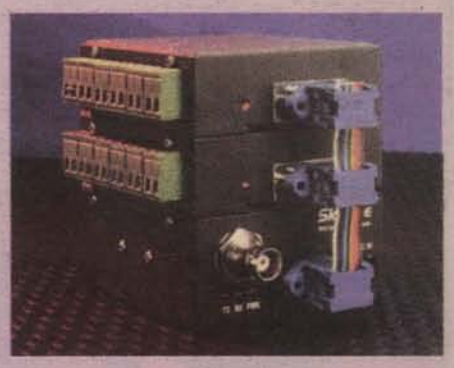

SkyLine wireless data communication products from Sonik Technologies are now available for a variety of applications, extending from simple point-to-point RF links to complex multipoint wireless data acquisition and control applications. SkyLine offers data transfer reliability, expandability, and ease of use.

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For more information, contact:

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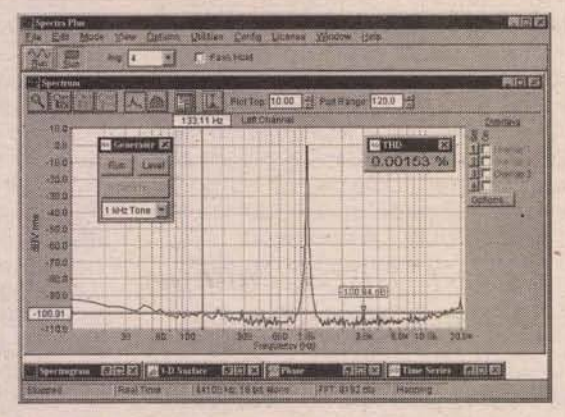

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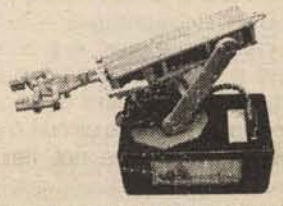

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TECH FORUM

Continued from page 49

This can make one or more of the "keys" inoperative in an otherwise functional unit. Does anyone manufacture a "paint on" conductive coating that can be recoated over these rubber membrane pads to restore them to original operation? I have tried the circuit trace compounds, but they are not flexible enough and tend to crack and peel off after a few uses.

39724 **Mark Albanese**
Plantsville, CT
mark.albanese@usa.net

I would like a transmitter/receiver pair that would communicate via ultra high frequency sound pulse(s). Ideally, the frequency would be tunable so several different transmitters could be distinguished.

39725 **J. McDonough**
Las Vegas, NV

We are looking for some software, containing libraries of electronic symbols for use with our Easy-PC Professional CAD Program. Our main interest is in the vacuum tube symbols. Any help or direction you can give us would be greatly appreciated.

39726 **Dick Rodgers**
via Internet

I recently acquired a handheld bar code scanner set-up which consists of a cordless wand reader (about the size of a cordless soldering iron) and a charger/docking station complete with serial PC connector. Unfortunately, the documentation wasn't available nor was any operating software. The unit takes a charge, and scans standard bar codes (evident by the beep tone when scanned). But, I have no way of extracting the information from the wand.

I tried calling several scanner distributors, but none have heard of the company. The vital information is:

Docking Station/Charger: MSI Datawell II. Model: 0303-00J. Part No: 51277-00-00

Scanning Wand: Part No: 51145-00-00

Any help in locating information on this item will be much appreciated.

39727 **Mark Albanese**
Plantsville, CT
mark.albanese@usa.net

Can you tell me how I can enable my Alinco DJ 580-T to receive and transmit on the GMRS channels? I have applied for a license and I would like to use this radio on these frequencies, using low power, of course.

39728 **J. Beattie KF2MY**
via Internet

I'd like to build a programmable LCD display that I can hook up to my crystal-controlled scanner, so that

Continued on page 109

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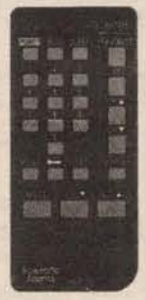

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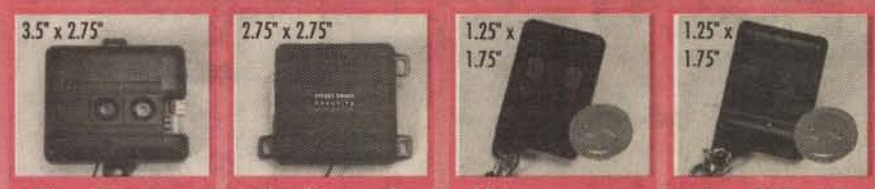

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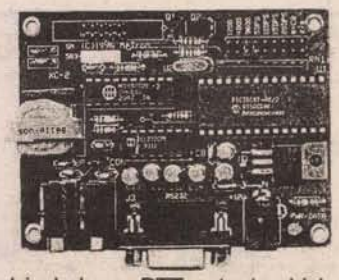

The New **MoTron XC-2** is a versatile bi-directional DTMF to ASCII transceiver. DTMF digits are decoded from the audio line, converted to ASCII, and transmitted out through the serial port. ASCII data is received from the serial port, converted to DTMF digits and transmitted on the audio line. The **XC-2** uses the RS-232C serial communications protocol and includes a PTT output, which can be used to control a radio transmitter. The **XC-2** is user-configurable–select either 1200, 4800 or 9600 baud for the serial port and 5, 10, 15 or 20 cps DTMF transmission rate. Additional jumpers can be used to set DTMF "#" to generate an ASCII "CR", and to control an open-collector output with DTMF "*" (on) and "#" (off). Audio connection options allow combined audio signals, or separate audio input and output via standard 3.5mm jacks. A standard DE-9S is used for serial communications. The **XC-2** is a fully assembled and tested printed circuit board, requires +8 to +17 VDC @ 200ma, and is only 2-1/2" x 3-1/2". OEM and Quantity discounts are available.

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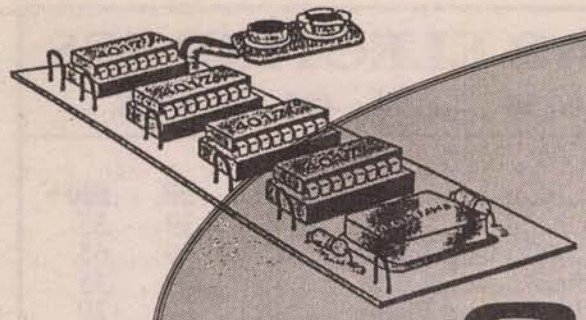


Build a Deluxe Timebase

by
Fred Blechman

If you have ever wondered about the accuracy of the dials and digital readouts on your frequency-related test equipment, the "Deluxe Timebase" can provide you with a simple and inexpensive means of calibration. Although it is not up to the National Bureau of Standards accuracy, it is certainly close enough for most experimentation and repairs.

The Deluxe Timebase can be built from mostly common parts, and is based on a $6.95 kit available from The Electronic Goldmine. However, this project adds a switch, binding posts, resistor, and LED (light emitting diode), and is built in a small box, as shown in the photos.

You can use the Deluxe Timebase directly to closely calibrate digital readouts of AM and FM radio receivers up to 30 MHz and probably higher. It can be used as a signal injector to trace signals in audio and radio frequency amplifiers. Used with an oscilloscope and Lissajous figures, as described later in this article, you can calibrate AM audio and RF signal generators. You'll probably find other uses as well.

Featuring five separate squarewave outputs (100 Hz, 1 KHz, 10 KHz, 100 KHz, and 1 MHz), the Deluxe Timebase is portable, powered by a common nine-volt battery, and can be packaged in a plastic case small enough to fit in your pocket.

Circuit Description

Figure 1 shows the Deluxe Timebase schematic. The heart of the circuit is the oscillator, X1. This integrated circuit crystal-controlled oscillator, when properly powered through current-limiting resistor R1 to pin 14, generates a square-wave output at one million cycles per second (1 MHz), plus or minus 50 Hz, at pin 8.

Since the internal oscillator in X1 is crystal-controlled, the output signal is very stable and precise.

The 1 MHz output signal of X1 is connected through current-limiting resistor R2 to pin 14, the clock input of IC4, a CMOS 4017B divide-by-10 counter. The counter divides the input signal by 10, producing an output signal on pin 12 of 100,000 cycles per second (100 KHz).

This signal is also fed directly to the clock input of IC3, another 4017B decade counter, resulting in a 10 KHz output. A similar divide-by-10 process is produced by IC2 and IC1, resulting in outputs of 1 KHz and 100 Hz, respectively.

The Deluxe Timebase uses a rotary switch to select any of five squarewave output frequencies. It can be neatly packaged in a Fuji slide box.

Basic Construction

You will have to look long and far to find a project this useful that is so simple to build. While a printed circuit board is not required, the layout for the one supplied with the kit is shown in Figure 2. The parts layout, which could just as easily be used with common perforated board having holes placed .1" apart, is shown in Figure 3.

You may have trouble finding the integrated circuit crystal oscillator, X1. If you buy the kit referred to in the Parts List, it is included. While 16-pin sockets for IC1-IC4 come in the kit, they are not actually required; you will only be soldering to six pins of the 16 pins on each chip. However, if one of the ICs go bad, you'll be glad you used sockets!

With only two resistors, the crystal oscillator,

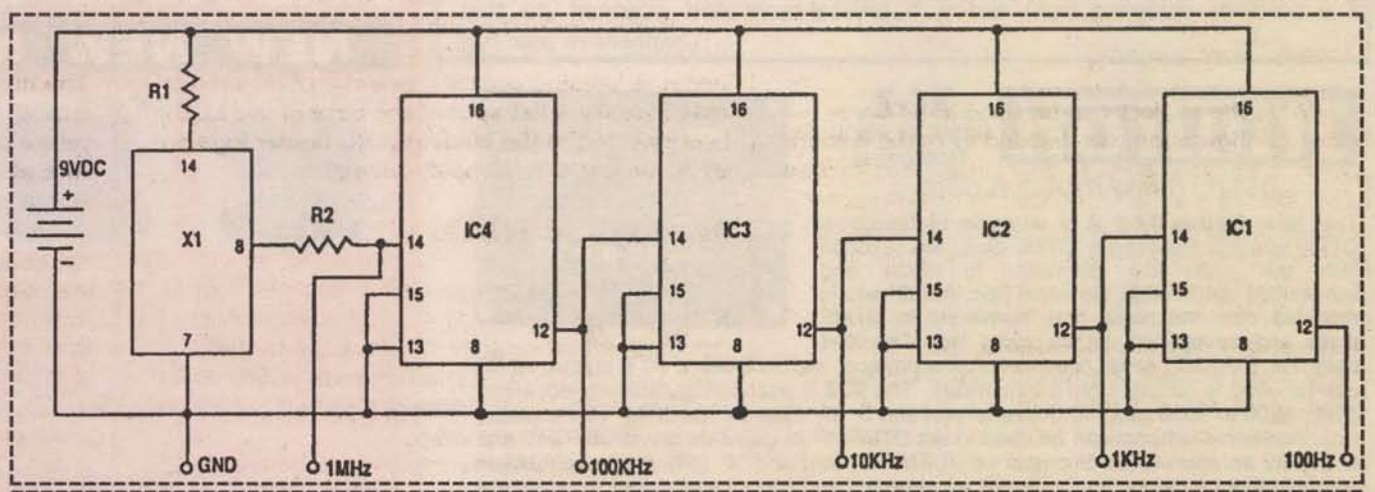


FIGURE 1: Schematic of the Deluxe Timebase Base Main Board

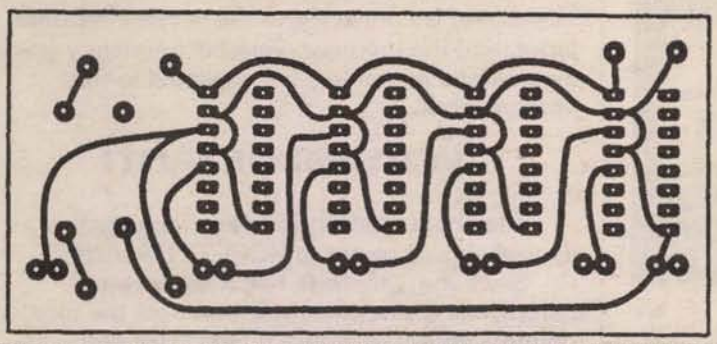


FIGURE 2: Deluxe Timebase Printed Circuit Layout

Figure 4 shows a wiring diagram of the added circuitry. The switch, binding posts, resistor, and LED were mounted on the box cover, with the battery and circuit board inside the box, as shown in the photos. If the switch comes with a long shaft, you'll want to cut it shorter with a hacksaw, leaving it long enough to use with a set-screw type pointer knob.

You must take care that you wire things properly to the switch. Use an ohmmeter to determine which switch terminals are in contact at each switch position, and make a pictorial diagram of the switch showing these connections.

monitor the output in this position. Alternately (and better), use an oscilloscope.

As you turn the knob clockwise, each detent raises the output frequency tenfold — 1 KHz, 10 KHz, 100 KHz, and finally 1 MHz. Your earphone probably will not have sufficient response at 10 KHz or above, but your scope should easily show these signals.

If you get no output at all, make voltage checks. Be sure each IC is oriented as shown in Figure 3. If the outputs seem reversed in frequency — going down as you turn the switch clockwise — you have miswired to the switch. If so, just switch wires at the output loops on the circuit board. If the LED does not light, you may have the cathode wired to the switch instead of the negative terminal.

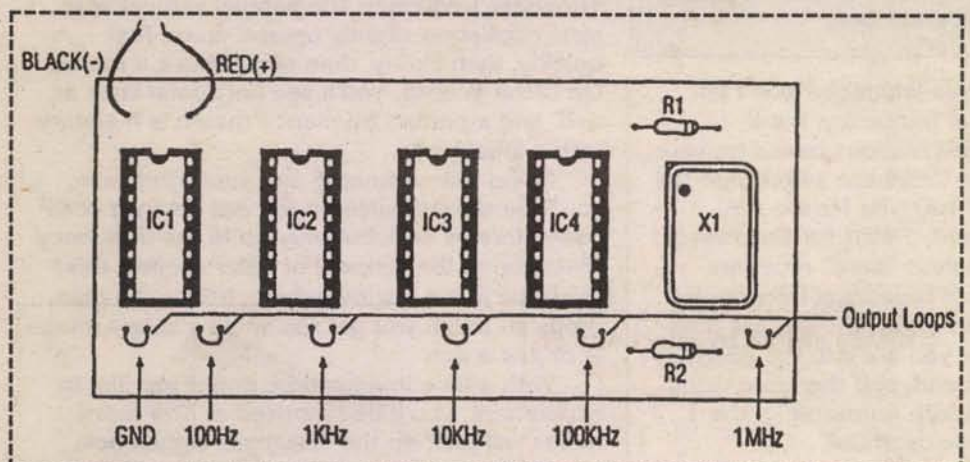


FIGURE 3: Parts Layout - Main Board. Be sure to orient X1 and the four ICs as shown.

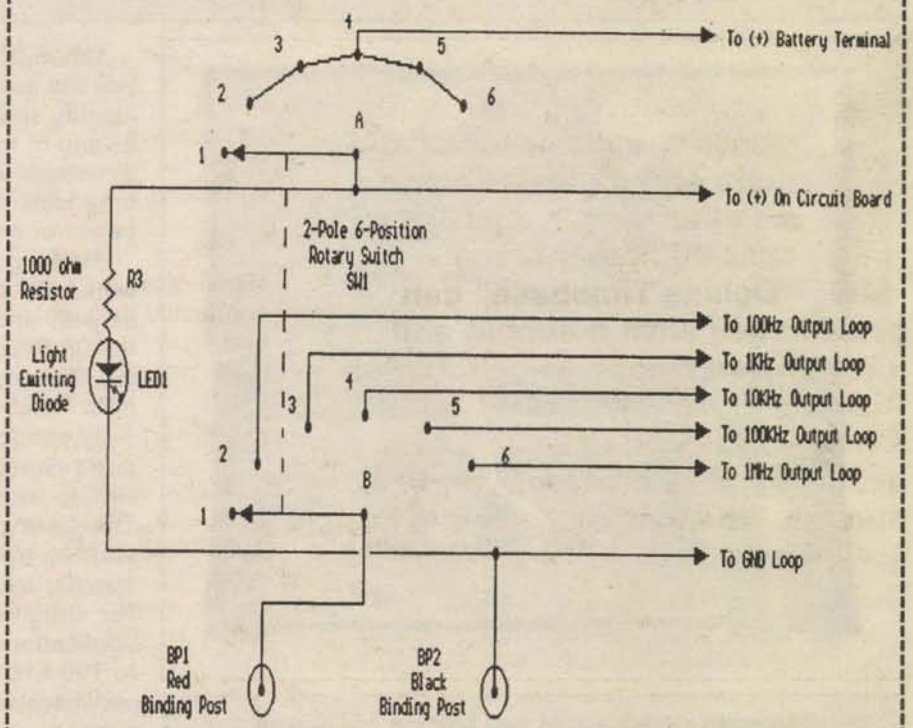


FIGURE 4: Switch wiring diagram, showing connections going to the main circuit board and battery.

and four integrated circuits, the assembly and wiring of the circuit board is relatively simple. Be sure the ICs and crystal oscillator are oriented as shown in Figure 3, and that the wires going to your battery are not reversed. *Applying reverse voltage to the ICs or crystal oscillator could ruin them instantly.*

Although the schematic shows a nine-volt battery for power, we found the circuit worked down to about three volts, although the output squarewave voltage was also reduced. The current drain from the batteries is also greatly reduced if you use less than nine volts. For example, we found the current drawn from a nine-volt battery was almost 15 milliamperes (15 mA), but only about 2 mA was used with a three-volt source.

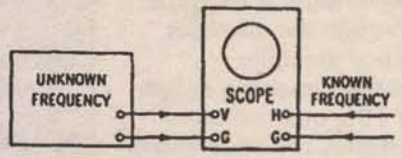


FIGURE 5: Typical oscilloscope Lissajous setup has known frequency applied to horizontal input, and unknown frequency to the vertical input. Set scope for Horizontal Input.

Deluxe Packaging

While the project can be used in its bare-bones configuration, we decided to make it more practical to carry around. Any plastic box can be used, but we used a Fuji Slide Box, commonly used to package 36, 35 mm slides. It is the perfect size for this project (4.5" by 2" by 1"), made from thin easily-cut plastic, and holds the circuit board and nine-volt battery perfectly. Most photo shops deliver processed 35 mm slides in these type of boxes, and have them available. We found some for 35 cents each!

We decided to use a two-pole six-position rotary switch to select the output frequency fed to two binding posts. The switch also is used to power the circuit, with an LED to show the unit is ON.

Referring to Figure 4, run wires from the circuit board to the proper switch terminals. We found flexible "rainbow" ribbon cable (adjoining wires are different colors) easy to use between the flip-open cover and the circuit board.

When connecting the LED and its current-limiting resistor between the switch and the negative binding post, be sure the LED cathode side (usually a flat spot at the base of the LED) is connected to the binding post. Solder lugs on each binding post simplify assembly.

Testing and Troubleshooting

Once the unit is assembled, turn the switch to its furthest counter-clockwise position and tighten a set-screw type pointer knob to the round switch shaft so that the knob points to the left. This is the OFF position. Connect a nine-volt battery to the battery snap.

When you twist the knob clockwise to the first position, the LED should light, and a 100 Hz squarewave should appear at the binding posts. You can use a typical eight-ohm earphone to

Using the Deluxe Timebase

Okay, you have a properly working Deluxe Timebase. What are you going to do with it? To check the accuracy of the dials and readouts on radio receivers, use the Timebase with a simple output coil as a "marker generator."

Suppose, for example, you want to check (or set) the dial or digital readout of an AM radio. Make an output loop from some hook-up wire. The number of turns and dimension are not critical. We used six turns of bare wire around a yellow pencil, leaving about two inches of bare wire at each end, then spaced the turns so the length of the coil was about .5".

We connected the ends of the coil to the Timebase binding posts, so the coil now became the output "antenna" to our Timebase "transmitter." Due to the huge harmonic content of the squarewave output of the Timebase, it radiates high multiples of its frequency setting.

By turning on the Timebase and holding the coil near a radio's antenna or innards, you'll be able to identify marker frequencies by either drastic quieting of the noise level, or whistling (heterodynes) caused by a received signal close to the Timebase frequency. You'll find that

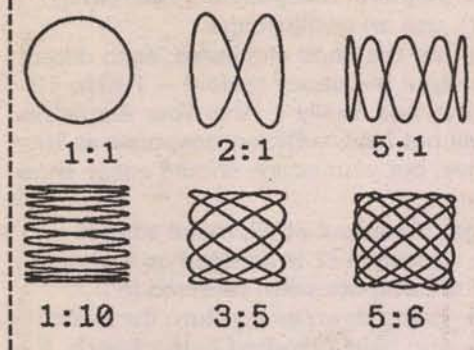
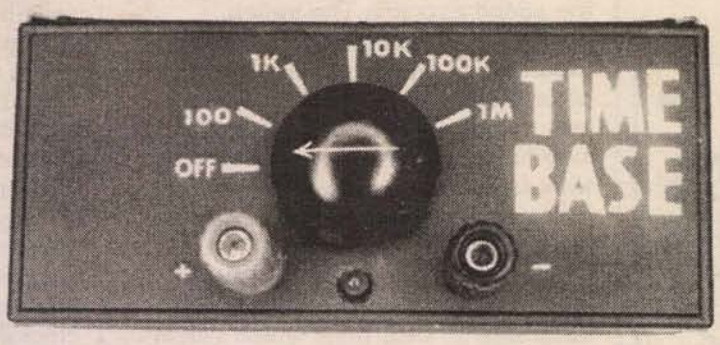
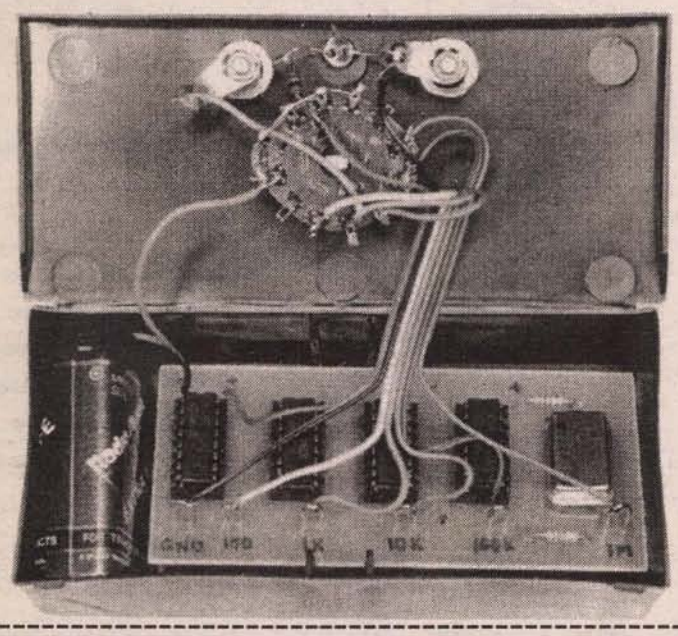


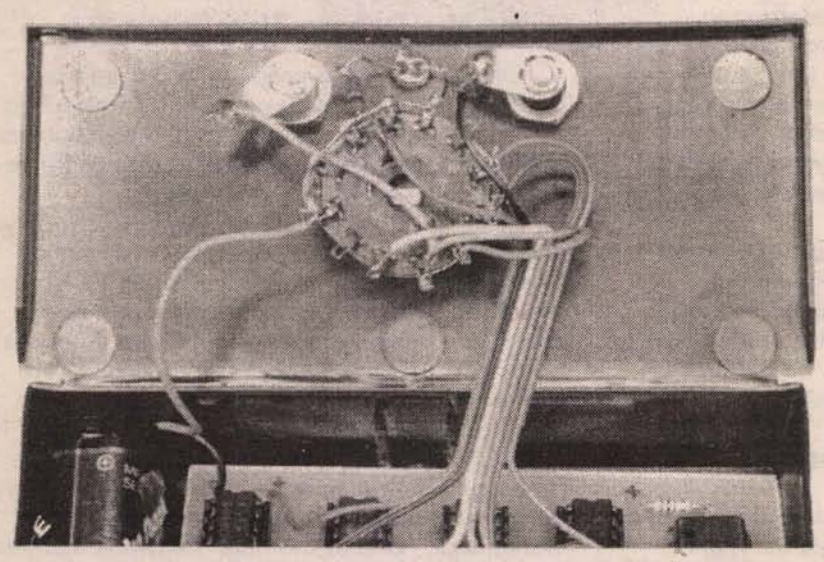
FIGURE 6: Lissajous figures using sinewaves. The ratios shown are vertical frequency to horizontal frequency if the set-up is as shown in Figure 5.



The Deluxe Timebase uses a rotary switch to select any of five squarewave output frequencies. It can be neatly packaged in a Fuji slide box.



The main circuit board and battery are placed in the bottom of the box, with ribbon cable used to connect to the multi-pole switch mounted in the box lid.



A two-pole six-position switch is mounted in the box lid, together with two binding posts, a resistor, and an LED.

moving the Timebase coil closer and further from the radio will help you clarify if the quieting or whistling you hear is resulting from the Timebase marker.

Although this technique won't tell you the actual frequency, it will identify spaced markers based on your setting of the Timebase switch. Set the Timebase to 100 KHz for the AM broadcast band, 1 MHz for shortwave bands or amateur "ham" receivers.

Marking FM broadcast frequencies works the same way, though not quite as well, since you are into the 88 MHz to 108 MHz band, and therefore using the 88th to 108th harmonic of the 1 MHz Timebase oscillator.

By connecting the output binding posts directly to audio amplifier circuits with clip leads, and setting the Timebase switch to 100 Hz or 1 KHz, you can trace audio signals from the speaker back through the amplifier. For radio frequency amplifier applications, set the Timebase switch to 100 KHz or 1 MHz and use an oscilloscope to display the squarewave signal through the components.

Used with an oscilloscope, you can use the Timebase to calibrate audio frequency (AF) and radio frequency (RF) generators. The connections are shown in Figure 5 to produce modified Lissajous figures.

Lissajous (Liss-a-Jew) figures? These are typically used with sinewaves to determine an unknown frequency. A known sinewave frequency is applied to a scope Horizontal Input, and an unknown sinewave frequency is connected to the scope Vertical Input.

Once the vertical and horizontal voltages are adjusted to produce a centered scope pattern of about equal vertical and horizontal size, either input frequency is varied until a circle appears on the screen. The circle may rotate, or you may get other patterns, as shown in Figure 6, for multiples of the vertical or horizontal frequencies.

For a full discussion of Lissajous figures, refer to a book on oscilloscopes. The purpose here is to describe the use, not the theory.

The known frequency (in this case, the Timebase) is connected to the scope Horizontal Input, and the unknown variable frequency (such as an audio generator) is connected to the Vertical Input.

VERY IMPORTANT!

The scope horizontal sweep frequency control should be set to HORIZONTAL INPUT.

Since the Timebase has a squarewave output, not a sinewave, you won't get the nice patterns shown in Figure 6. You'll see two vertical parallel lines. When the unknown frequency is varied and approaches the Timebase frequency, the parallel vertical lines start oscillating slightly up and down, first quickly, then slowly, then stop. That's a match! On better scopes, you'll see horizontal lines as well, and a perfect frequency match is a square with a little twist.

Using this technique and your Timebase, you'll be able to calibrate the dial settings of RF generators as well, but only up to the frequency limitation of the scope. For older scopes, this might be just a few megahertz before the gain drops so much you get too small a scope image — or just a dot!

With a little imagination, and if you like to experiment, you'll be surprised at how many radios will pick up the Timebase signal, how effectively you can trace signals through an amplifier, and the variety of Lissajous patterns you can generate on your scope. **NV**

PARTS LIST

BP1, BP2 - Red and black binding posts (Radio Shack 274-662)

IC1, IC2, IC3, IC4 - CMOS 4017B integrated circuit

LED1 - Red LED, standard size

R1, R2 - 100-ohm 1/8-watt 10% carbon resistors

R3 - 1000-ohm 1/8-watt 10% carbon resistor

X1 - 1 MHz crystal-controlled oscillator IC (see text)

SW1 - Rotary switch, two-pole six-position (Radio Shack 275-1386)

Miscellaneous: Etched and drilled printed circuit board, Fuji slide box, four 16-pin sockets, battery snap, knob, 6" bare wire.

A Timebase Kit, which includes all the ICs, sockets, R1, R2, X1, battery snap, and a drilled and etched printed circuit board (but not the additional parts shown for this project) is available from **Electronic Goldmine**, P.O. Box 5408, Scottsdale, AZ 85261 **(602-451-7454)** as #C6717 for $6.95.

However, minimum order is $10.00, so call for their free catalog; you'll find lots of other things to order! Shipping is $4.00 per order. Call for foreign shipping. California residents add sales tax.

Continued from page 105

instead of just seeing an LED on a certain channel, I could see who was really talking. Since the scanner is a crystal unit, I won't be changing frequencies often, so it need not be easily reprogrammed. But it is a mobile application, so the circuit must be capable of running off 12 VDC. Any ideas out there?

39729 **J. M. Povich**
Bridgewater, NJ
jpov@juno.com

I am looking for a method to detect 60/50 Hz power lines above or below ground. I would like a method that indicates roughly how close one is approaching the power line or at least responds somewhat linearly as distance changes. A bonus would be to determine the orientation of the power line.

39730 **Gus Calabrese**
Denver, CO

I am looking for a circuit diagram for a Black & Decker battery charger used to charge the drill motor battery on a 9.6-volt drill. The charger is called "Univolt Charger" model 98014, type 2. It has a blown diode and possibly a blown transistor and voltage regulator.

39731 **Berge Jermakian**
himart@aol.com

ANSWERS

ANSWER TO #2974 - FEB 1997

Assuming you want to cut a continuous line through the wood, 20 watts should do the job. I'm not familiar with bass wood, but balsa is very soft and should present no problem for a 20-watt Yag laser. In the March '96 issue of *Nuts & Volts*, I wrote an in-depth answer to the same problem with the material in question being cloth. The parameters for cloth are similar to what you will encounter, and this answer should explain all of the cost and problems you will face.

Chris
Bieber, CA

2 ANSWERS TO #2976 - FEB. 1997
ANSWER #1:

A simple way to measure water temperature in a 3,600-foot deep mine shaft would be to utilize a new product manufactured by Dallas Semiconductor. The new device is an addressable temperature sensor which is packaged in a two-lead TO92 package. These devices are installed in parallel across a two-conductor twisted cable.

In your application, a minimum of 36 devices would be placed at 100-foot intervals along a 3,600-foot twisted pair cable. The cable would then be installed into a waterproof tube which would then be flooded with silicon rubber to form a durable and waterproof assembly. The tube would then be weighted at the lower end and supported with a suitable bouy at the upper end. The upper end of the cable would be connected to the serial port of a PC.

Software created by Dallas Semiconductor is used to interrogate each device by its unique serial number. Each device would report the surrounding temperature via serial data. You should consider placing two or more sensors at each test location for redundancy in case of failure so that the entire assembly would not have to be repaired or replaced.

Joe Leikhim
Tallahassee, FL
Jleikhim@nettally.com

ANSWER #2:

Your desire to probe the temperature at depths up to 3,600 feet presents a varied and interesting problem. As you know, that depth represents a gauge pressure of 1,440 psi — enough to crush most unprotected delicate electronics. Plus, you need to do this economically.

I recommend a simple data logger. Since data cannot be (practically) sent up the spool of wire, I would use a turned aluminum container sealed with an o-ring (an old centrifuge "bomb" would do just fine!) and lowered on .070" aircraft cable. The circuit would consist of five elements: **1)** a Parallax BS2-IC [$60.00]; **2)** a Dallas 1620 temp chip [$2.00]; **3)** a U-CMOS clock chip and crystal [$6.00 and optional]; **4)** a small strain gauge, amplifier and Dallas A/D chip [$10.00]; and **5)** a nine-volt battery [$2.00]. Throw in a circuit card and hardware, and we

Continued on page 111

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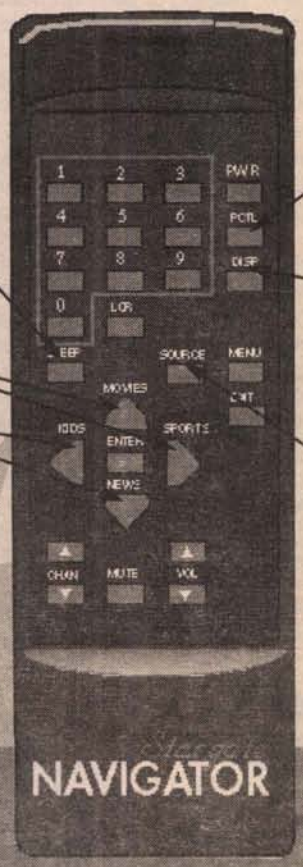

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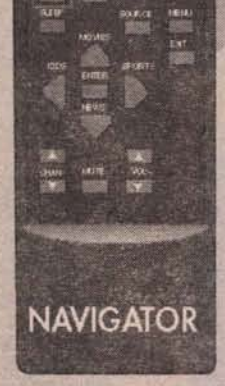

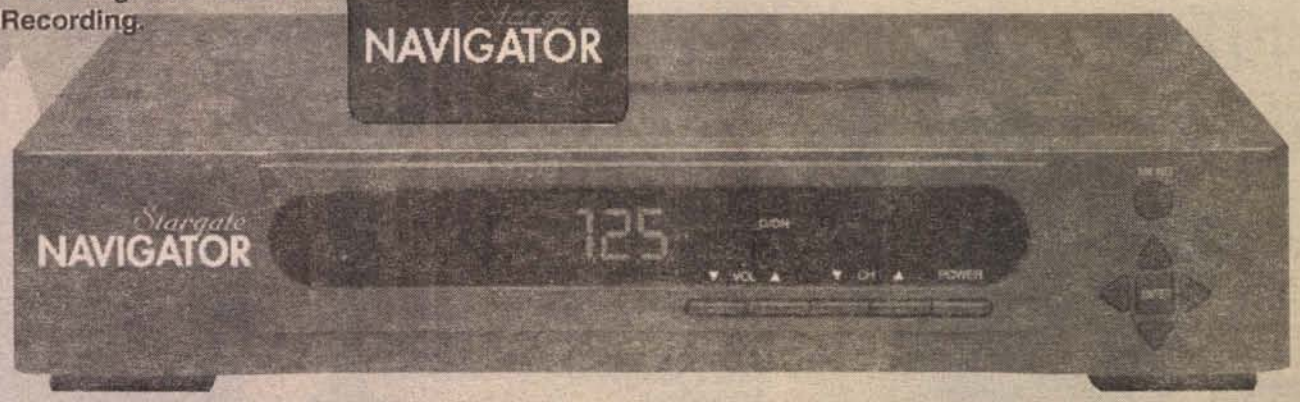

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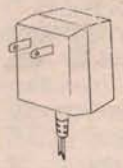

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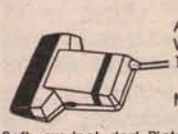
Available 16-Bit Interface slot, Windows 3.1, 4 Meg RAM, 10 Meg of Available HD space (Min.), Mouse or Other pointing device.



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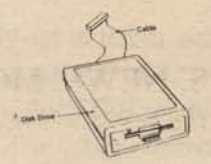

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FF-3101/700 Combo ..... $69.99 Ea.

Write in 135 on Reader Service Card.

TECH FORUM

Continued from page 109

have a complete system for around $ 90.00.

My approach would be to bond the strain gauge on the bottom or side of the container and proceed thus:

1. Lower container, sense strain converted to serial and fed to the BASIC Stamp ... until;

2. Set depth is reached (every 100 feet = every 40 psi increase in pressure) ... then;

3. Take a temperature reading from the 1620 chip; take a time reading from the UCMOS clock and store them in the Stamp's scratchpad.

4. Recover and display data on your PC.

Since the (optional) clock is on board, you could log temp data at any given depth, until the 2,000-byte memory of the Stamp (less program) is full. Since you want every 100 feet, that's only 36 readings per pass, leaving you lots of room for time-lapse logging.

I hope this gives you some ideas. If I can be of help, just drop me a line!

Hank Hamarman
Owl@Who.Net

ANSWER TO #2975 - FEB. 1997

If you intend to run the intercom a short distance of less than a couple of hundred feet, then a simple DC power supply of around five volts, 0-50 mA should power the speed circuits. The ringer circuit can be powered directly from the AC wall power stepped down through a dropping resistor.

Telephones in the US are designed to run off of approximately five volts DC (off hook) at around 5 to 20 mA for the voice, and approximately 70 to 90 volts AC (20 Hz, 1 to 25 mA) for the ringer. The voltages vary from area to area, but these voltages will work on any US telephone as long as you are using relatively short distances of a couple of hundred feet or less.

You can use batteries or a wall-powered transformer to power the speech circuit, but if you use a transformer, you will have to filter the power a little more to remove the 60 Hz hum. Because the telephone circuitry is sensitive, you will need to add a filter to condition the power that comes out of the transformer. You can accomplish this with any over-the-counter filter blocks (line conditioners), or you can build them yourself from scratch. If you don't condition the line that powers the phone, you will hear a 60 Hz hum that could be anything from barely audible to very annoying, depending on the handset you chose and the transformer's filter, if any.

If you are thinking of using longer distances, then you will want to copy the phone company's circuitry which is more complex, but will ensure that you have no problems when using distances of 500 feet to several thousand

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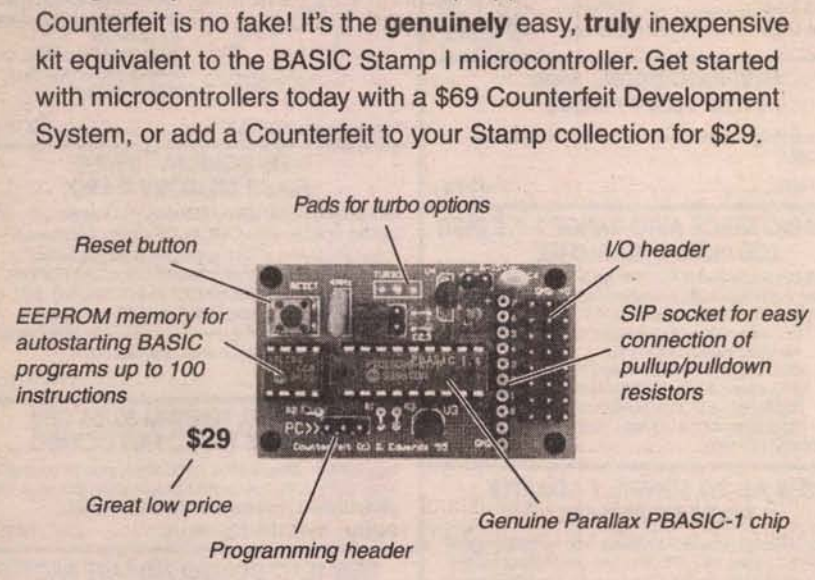
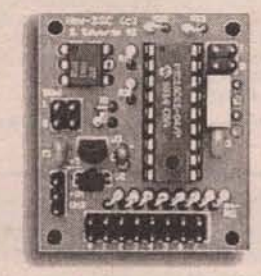


Mini Serial Servo Controller



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Write in 70 on Reader Service Card.

TECH FORUM

feet. The power used for long distance is around 48 volts DC and the system requires dropping resistors and coupling transformers at both ends.

Running the phone off of a battery will eliminate any hum, and if you couple a dropping resistor from the feed line, you can use a 12-volt car battery to run the system for months at a time between charging. Even 4 "D" cell batteries only draw around 5-20 mA of power.

If you are using any length of wire — 100 feet or more — you should step up the voltage slightly to around 6 to 7.5 volts to overcome the resistance in the wires, but this may not be necessary depending on who manufactured your hand set. The minimum voltage to run most sets is around 3.5 volts and voice distortion occurs at around 10-12 volts in some hand sets.

To simplify the power for the ringer, you can use the 120-volt, 60 cycles directly from the wall socket simply by adding a dropping resistor of about 10,000 ohms or more, in line, to drop the current and voltage levels to a safe limit that will both ring the phone and protect against electrocution. You can experiment with a 100K potentiometer and a 5,000 ohm resistor which will allow you to achieve the volume that you desire.

To simplify the ring and off-hook requirements, you should add two zener diodes back-to-back into each phone assembly after the ringer — in line with the receiver circuit — of around 15 volts, one watt, to protect the handset from accidental ringing when the handset is picked up. The zeners are placed essentially as a short in the event that a handset is picked up while the ringer circuitry is activated. If this happens, the zener diodes will conduct at ground 15 volts and will effectively short out the incoming 120 volts, 10 mA ring. This will protect both your ear from excess noise in the ear piece, as well as protect the speech circuitry from excess voltages which can ruin some of the more modern IC-type telephones and foreign cheaper types.

Although the standard ring cycle is only 20 cycles, 60 cycles will ring the bell or electronic ringer. You can purchase a special transformer assembly which divides the cycles into three groups of 20 Hz, but this route is expensive and the 60 cycles coming from the wall socket will ring the phone just the same.

Chris
Bieber, CA

ANSWER TO #2973 - FEB. 1997

Question #1: Can you use your old Caller ID decoder as a DTMF tone reader? In a nutshell: No. The CID information is transmitted as a serial bit stream; you might think of it as similar to modem signalling. Each DTMF digit consists of two discrete audio-frequency tones, one from the "high group" and one from the "low group." The circuitry needed to decode CID is entirely different from what is needed for DTMF, so about the only common hardware is the display itself. It would be much easier to design a DTMF box from scratch, or to build one from a kit (several are advertised in *Nuts & Volts*). I personally built a kit from Weeder Technologies which decodes the DTMF signal and sends it to my old computer. I use the computer to display the number and to log in the calls. (In the future, I hope to expand this to an "intelligent" answering system which only accepts calls from numbers that it recognizes.)

Question #2: How do you find the detector in your FM receiver? If you don't have a schematic, the best way is to start at the top end of the volume control and work your way back toward the RF section. As a simplification: the broadband demodulated signal comes out of the detector, goes through a low-pass filter to recover the mono L+R audio signal, and also goes through a high-pass filter to recover the 19 KHz stereo pilot and the modulated 38 KHz subcarrier. The subcarrier is then demodulated to produce the L-R audio signal, which is combined with L+R to produce the discrete left and right channel audio which ends up at the volume control. Hopefully you can follow the signal path back to the discriminator from this description. This assumes that your receiver is old enough to contain more or less discrete circuitry; some newer receivers have almost everything on one IC, and the direct output from the detector may not be available.

Greg Miller
State College, PA
a.v.guru@juno.com

Continued on page 115

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Write in 71 on Reader Service Card.

Software Wizardry

by Harry Helms

A Look Inside Next-Generation Operating Systems

When I first started writing this column, I stirred up a hornet's nest by stating that it would focus on Windows-based software and systems. I said I would do so because the vast majority of software development involved Windows, not because of any inherent superiority of Windows.

Boy, was that a mistake! Partisans of OS/2, the Mac OS, Unix, etc., quickly took me to task for ignoring their favorite operating systems. I quickly discovered that people can get just as passionate about their favorite operating system as they can about programming languages.

I shouldn't have been surprised; operating systems ARE important. And, like programming languages, operating systems are undergoing major changes as the transition to 32-bit applications really accelerates. A host of capabilities formerly restricted to high-end operating systems like Unix will soon start appearing in new versions of Windows and the Mac OS. You'll need to become familiar with a new set of buzzwords and concepts to understand the benefits these improvements will offer users and developers. This month, we'll discuss these buzzwords and concepts, and how they will likely be implemented in future versions of Windows.

To cover my backside this time, let me say that I wish I could discuss future versions of the Mac OS in detail, but Apple's recent acquisition of NeXT has left their OS plans very much up in the air. And a lot of what I have to say about Windows NT 4.0 also applies to OS/2, since both began in the same joint IBM/Microsoft development groups. My decision not to discuss OS/2 in detail is strictly a function of its market share; no judgment on its technical merits or usability should be inferred!

Core Components

Three terms are used today when talking about almost any operating system. These terms are: kernel, user, and graphical device interface (GDI).

The kernel is the lowest level of an operating system, but it may be the most important. The kernel handles such fundamental tasks as memory management, file management, basic input and output, task scheduling and synchronization, and handling of exceptions and interruptions.

The user level is where the user interface of an operating system is implemented. The user manages windows, icons, menus, and other elements used to manipulate the various features of the operating system. The user level accepts input from the keyboard, mouse, and other devices and also manages output to sound cards and communications ports.

The GDI is the "highest" level of an operating system, as it is here that the monitor display is controlled. Every pixel on the video monitor is manipulated by the GDI. The GDI also interfaces with drivers for various graphics devices. If you print out a bitmap image on a printer, you're using the GDI.

Not all operating systems will use these terms to describe their different components (although kernel is commonly used, and so is GDI). But most contemporary 32-bit operating systems – including Windows 95, Windows NT, and OS/2 – are organized along these lines.

The Search for True Multitasking

True multitasking – the ability of a PC to run two or more applications simultaneously – has been something of a "Holy Grail" of computing. A lot of time and effort has gone into achieving that goal, but the results to date have been disappointing.

One big impediment has been in the hardware. It takes a lot of computing horsepower in the processor, plenty of memory, and a fast bus to support multitasking. For a long time, PC hardware was just not up to the task. Thankfully, things have changed for the better. Pentium and PowerPC microprocessors have plenty of muscle, the PCI and similar busses can move data around quickly, and memory is relatively cheap. Implementing multitasking is now primarily a software problem.

The Macintosh was the first PC to attempt a form of multitasking. Since graphical interfaces are so common these days, it's difficult to imagine what a revelation it was to be able to have two windows open – like those for MacWrite and for MacPaint – and to be able to toggle between those applications with a mouse click. But this wasn't really multitasking at all, since only one application could be running at a time. If you were using MacWrite, MacPaint was, for all intents and purposes, shut down. Moreover, the system could handle only one task at a time. If you wanted to print a copy of a MacWrite document, then the processor was totally consumed with the printing task. You couldn't work on another document or any other application until the printing had finished.

The solution was to use threads.

The "thread" was a concept that had been bouncing around scientific and academic computing circles for several years. A thread can be thought of as a small task that can be executed independently of other parts of a program, somewhat analogous to the concepts of atoms and molecules. All software – applications, operating systems, etc. – are composed of multiple threads. An example of a thread might be to read or write a byte into a certain memory location or to set a pixel to a designated color value.

The term "thread" is really descriptive. Look at the threads making up your shirt or pants. Each is independent from the others, yet they combine together to create a complete clothing "application" like a shirt. Each thread is "executed" (woven) separately during the weaving process to create the final product.

Using threads made it far easier to run two or more applications simultaneously. One thread of a word processing program could be executed ... then a thread of a drawing program could be run ... and then another thread of a word processing program could be run. In this way, both applications could share the microprocessor without one of the applications being shut down.

That was the theory, at any rate. In practice, things didn't work out that way. Versions of Windows prior to Windows 95 used a system known as cooperative multitasking. This meant that decisions as to which threads to execute from which programs were left up to the individual applications programs. An applications program could relinquish control to other applications either voluntarily (such as after expiration of a certain amount of processor time) or by checking a message queue to see if other applications needed the processor. For several reasons, which we'll discuss later, this didn't work well at all. A poorly written application could control the microprocessor and refuse to give up control to other applications.

The solution was something called pre-emptive multitasking. IBM's OS/2 was the first PC operating system to implement this. In pre-emptive multitasking, the microprocessor allocates a certain amount of time (approximately 20 milliseconds for Windows 95) to each application. When the time expires, the processor switches to the next waiting application. In this way, it is impossible for any application to monopolize the microprocessor. The rapid switching between applications gives a very good approximation of two or more applications being executed simultaneously.

The only problem is that two or more applications really aren't being executed simultaneously under this arrangement. The microprocessor still can execute only one task (or thread) from a single application at a time. If the processor is handling a thread from a word processor, then threads from a drawing or spreadsheet application will have to wait.

If you really want to run two or more applications simultaneously, the only true solution is multiprocessing.

Pedal-to-the-Metal Multiprocessing

Multiprocessing is a simple concept. Two or more microprocessors are used. While one of the microprocessors is busy with one task, the other microprocessor is busy with another task. Depending on the operating system and applications, the two processors could be running two different applications or different threads from the same application.

Multiprocessing was what made the first supercomputers super. Multiprocessing was clearly in the minds of microprocessor designers even in the early days. The Intel 8088 processor used in the first IBM PCs soon had a companion math co-processor chip. The math co-processor handled complex math operations for the 8088, freeing it for other tasks. But true multiprocessing had to wait for improvements in PC operating systems.

OS/2 was once again the first PC operating system to support multiprocessing, but once again IBM's strategic mistakes and inept marketing prevented it from gaining widespread use. Windows NT 4.0 is now the main platform for multiprocessing on Intel-based PCs. The main method for implementing multiprocessing on PowerPC hardware is the Be OS used on Be Computer's BeBox PC.

Multiprocessing systems can be either

asymmetric or symmetric. In asymmetric multiprocessing, each multiprocessor handles a specific set of tasks. For example, one processor might be responsible for the operating system and a second processor might be dedicated to running applications. The drawback here is that the processing demands on the multiprocessors can vary widely; it's possible for one processor to be heavily burdened while the other is almost idle. By contrast, symmetric multiprocessing allocates various tasks to all processors in a way to try to achieve an equal load on them.

One of the most fascinating things about the Be OS is the visual bar graph display of the processing loads on its two PowerPC processors as it executes applications. And the result is more than just a pretty display; the increase in performance over a single processor PC is truly remarkable. As operating systems that support multiprocessing become more widely used, I expect multiple processor PCs to become very common in the near future.

Synchronizing and Scheduling Threads

The use of threads in multitasking operating systems solves some crucial problems, but it also introduces some new ones. For example, how does the operating system decide which thread to execute first? Some applications require that several threads be executed sequentially for proper operation; interrupting processing to execute "competing" threads could crash the application. Moreover, some system resources cannot be shared by threads from different applications (it's hard to multitask a printer or video display!). For best results in multitasking systems, some method must be used to coordinate different thread execution and to assign them some sort of priority for their execution.

The methods used in Windows 95 for thread synchronization and scheduling are typical. A thread can exist in three possible states: running, ready, or waiting. A running thread is one that is currently being executed. A ready thread is one that can be executed whenever the operating system decides to execute it. A waiting thread is one that cannot be executed until some event occurs, such as an input or output operation or receipt of a message such as a mouse click.

In Windows 95, threads in the ready state are assigned one of 32 possible priority levels and are executed in order of their priority. These levels range from 0 (the lowest; the thread will be executed only if no other threads are waiting to be processed) to 31 (the thread will be executed before any other thread).

The priorities 0 to 15 are assigned to what are known as "variable priority" threads, while priorities 16 to 31 are assigned to "real time" threads. Not all thread priority levels are always used. For example, the highest priority among all threads in the ready state could be just 15. In that case, threads having that priority level will be executed first.

Thread priorities are assigned by the operating system's thread scheduler(s). Windows 95 uses two thread schedulers. The primary scheduler makes sure that the highest priority thread is running. The secondary scheduler has the more difficult task of adjusting thread priorities to make sure that multitasking works smoothly. (This process is sometimes referred to as dynamic priority adjustment.)

The primary scheduler examines all threads awaiting execution and selects the highest priority thread for execution. If two or more threads share the highest priority level, then the thread associated with the window that currently has focus is selected for execution. If two or more threads in the window with focus share the highest priority level, then the one associated with a task in the window foreground is selected for execution.

The primary scheduler only looks for threads with the highest priority level. As far as the primary scheduler is concerned, any thread not having the highest current priority level simply doesn't exist. This means that some low priority threads could have a long wait to be executed. To prevent this, the secondary scheduler will raise the priority of a low priority thread that is not executed within a certain time frame.

Let's suppose a thread begins with a priority of 5. If it hasn't been executed within a certain amount of time, the secondary scheduler might bump its priority to 10. If the thread still isn't executed within a certain amount of time, it might be boosted upward again to 15 or so. The secondary scheduler will repeat this process as necessary until finally the thread reaches the highest priority and is run.

Windows 95 (and other 32-bit operating systems) use several methods to synchronize the execution of different, unrelated threads, especially those that access or place demands on scarce system resources such as RAM. When a thread is executed, it can provide an event notification, or message, to one or more waiting threads that it has been executed. The number of threads that can access a given resource can be limited by a semaphore. (The term "semaphore" comes from railroads, where a semaphore was a signal used to restrict the use of a section of track to a single train.) The program that controls the resource is said to "own" the semaphore for that resource, and sets the maximum number of threads that can access the resource. A mutex is similar to a semaphore, but can be accessed by only one thread at a time.

Messaging

One thing that Windows, the Mac OS, and OS/2 all have in common is that they are message processing systems. All events – clicking a mouse button, pressing a key on the keyboard, moving the cursor into or out of a certain area of the display, etc. – in those operating systems produce messages that are processed by the operating system and/or its applications programs.

When an event generates a message, it is placed in a message queue for processing. The operating system and applications programs will periodically check the queue for messages. Depending on the needs of the applications program, many (if not most) messages in the queue will simply be ignored.

Consider what happens when you click an area of the display with the mouse. A "button click" message is not the only message that event could generate; it could also generate "button down" (when the mouse button is clicked) and "button up" (when the mouse button is released) messages that make up a single "button click" message. Depending on the application, any or all of these three messages produced by the mouse click event could be processed.

One of the big drawbacks of Windows 3.1 and other 16-bit operating systems was that all applications shared a single message queue. This meant it was easily possible for one application to seize control of the message queue and "hog" it, blocking messages from all other applications. Worse yet, if any of the applications sharing the message queue were to crash, all other applications sharing the queue would also go down since their messages would be blocked.

By contrast, 32-bit operating systems like Windows 95, Windows NT, and OS/2 provide a separate 32-bit message queue for each thread of all application programs running. If one of the applications goes down, the others are unaffected. However, this is true only of 32-bit applications specifically written for the operating system; if you run 16-bit Windows 3.1 software under any of those three 32-bit operating systems, then you still have applications fighting to use a single 16-bit message queue.

Improved File Systems

One thing has remained constant from the introduction of MS-DOS in 1981 clear through Windows 95: the file allocation table (FAT) system for file management. As you might imagine, the FAT system is a technical dinosaur.

Under FAT, disk space (whether a floppy or hard drive) is organized using a sector (512 bytes) as the smallest unit. Depending on the storage medium, disk space is allocated in clusters consisting of a set number of sectors. On a high density (1.2 meg) floppy, there is one sector per cluster. However, a cluster consists of 64 sectors (for a total of 32,768 bytes) on hard drives of one gigabyte or greater capacity. Since FAT allocates disk space by clusters instead of sectors, this usually results in a lot of wasted disk space.

For example, suppose you want to save a 40K file on a one gig hard drive. Since one cluster can store a little over 32K, you would need two clusters to store the entire 40K file. However, most (about 25K) of the second cluster would be unused. The unused space in the second cluster would not be available for storage of another file. Almost all files stored will have a substantial portion of the "last" cluster empty, meaning that a large portion of hard drive space (perhaps as much as 20%) will be wasted.

FAT also limits the root directory of a drive to no more than 512 entries. FAT uses linked lists to search for a desired file. A file's directory entry will have the beginning FAT entry number for the first cluster used by that file. Each cluster will have the FAT entry number for the next cluster or a marker indicating the end of the file. While this system works fine for smaller files, it becomes more time consuming with larger files, especially as fragmentation increases.

A final problem is the loss of data if the FAT becomes corrupted. Most of you have probably had the experience of "losing" the FAT for a disk, meaning the file structure is lost. With PCs containing crucial business and financial data, some sort of "recoverable" file structure becomes a necessity.

The very serious attempt to improve upon FAT was the high-performance file system (HPFS) introduced by OS/2 version 2.1. Support for HPFS was later included in Windows NT. HPFS featured improved sector/cluster management, improved file structure, and vastly improved recoverability compared to FAT. Unfortunately, OS/2's failure to take off in the marketplace and build a sufficiently large user base doomed HPFS from achieving wide acceptance as a replacement for FAT. The current version of Windows NT, 4.0, drops support for HPFS and Windows 95 does not support it either.

The most logical successor to FAT now appears to be the Windows NT file system (NTFS). Introduced in 1993, NTFS was designed specifically for large disk drives and files. In fact, current versions of NTFS cannot support floppy disks since NTFS imposes a 5 meg "overhead" on each drive it supports. (Off the record, Microsoft personnel say they expect today's 1.4 meg "high density" floppy drives to be replaced in the near future by the 100 meg Iomega "Zip" floppies, thus making the 5 meg overhead requirement a non-factor.) How big a drive can NTFS support? Well, it can support up to 16 exabytes of data. How much is that? Well, an exabyte is equal to 1024 petabytes. A petabye is equal to 1024 terabytes, and a terabyte is equal to 1024 gigabytes. In other words, NTFS is today able to support disk drives that have not yet been developed!

NTFS also allocates disk space as clusters. The

Soft

cluster size depends on the size of the disk drives. For disk drives of less than 512 megabytes, the cluster size is 512 bytes. For disk drives between 412 megs and one gigabyte, the cluster size is 1024 bytes. For drives from one to two gigabytes, cluster size is 2048 bytes. For drives of two gigabytes or greater, the cluster size is 4096 bytes. These smaller cluster sizes result in far less wasted disk space than under FAT.

Perhaps the biggest advantage of NTFS over FAT is its recoverability. Under FAT, the data on a disk can easily be lost if the file allocation table becomes corrupted or lost, or if there is a general system crash. NTFS uses a database-like model to handle all "transactions" like reading or writing to a drive. There is no file allocation table to become corrupted; if a transaction does not execute completely and correctly, it is totally removed from the system and the drive is just as it was before the transaction was attempted.

NTFS also provides for greatly improved security over networks. Access to directories and files within directories can be restricted to designated users and be password protected. Access to files can also be designated as read only or to allow full read and write privileges. This is a marked improvement over FAT, which has no directory and file security features.

The one big drawback of NTFS is that it is not compatible with FAT or operating systems supporting FAT. For example, Windows 95 can recognize NTFS files on a disk, but it can't read, write, or otherwise access NTFS files. One solution would be to have separate FAT and NTFS partitions on a hard drive, but this is usually more trouble than it's worth. The best solution is to decide on one file system and stick with it. NTFS does allow importing and "upgrading" FAT files when you're ready to make a clean break with FAT, which usually means when you're ready to replace Windows 95 with Windows NT.

Which operating system will triumph in the future? Microsoft has indicated they expect some version of Windows NT to eventually be the standard PC OS, both for stand-alone and networked PCs. For Mac hardware, it should be an interesting race between NeXT and the Be OS, especially now that Microsoft has announced it will not be releasing upgrades of Windows NT for PowerPC systems.

Regardless of which system triumphs (or systems triumph), look for multitasking, multithreading, multiprocessing, improved system security, and improved file system management to be standard features of all PC operating systems in the near future. The real winners of this OS war will be developers and users! NV

TECH FORUM

Continued from page 112

ANSWER TO #2971 - FEB. 1997

The batteries called out for in the operator's manual for the Simpson 260 series 5P multimeter are as follows: One 1.5-volt D cell (Eveready #950 or equivalent) and one 15-volt (Eveready #417 or equivalent).

Finding a supplier for the 15-volt battery may be difficult. I found it in a 1990 Newark catalog (Newark #49F1080) for $13.37. However, it appears it is now discontinued since it is not in the 1996 catalog.

This 15-volt battery is used for the high ohms range and the overload protection circuit. if you use another type of battery to replace this one, check the Rx10,000 range to be certain that proper zero adjustment is possible. The tester is designed so that the protection circuit will function normally as long as the high ohms range can be set to zero.

R. R. Dunn
Modesto, CA

ANSWER TO #1977 - JAN. 1997

Black and white hand scanners are so cheap now, why worry about buying a card and software at some inflated price? Just go buy a new one. Check the advertisements in *Nuts & Volts* for some closeout deals. Most hand scanners use proprietary communications and software drivers. The company is likely out of business, as are a lot of small computer companies. Even some of the biggies (like Reveal) are no longer in business. Once the company goes away, the support all but dries up. I checked all my sources and couldn't find any record of the name either.

Rick Nelson
Newport News, VA
nelson@jlab.org

ANSWER TO #1973 - JAN. 1997

The source power supply for your laptop is higher than the battery voltage so it can charge the battery. Either resistor or active current limiter/charger control circuit would be used to allow the battery to charge at the appropriate rate. The AC chargers/adapter generally functions in two parts — namely charging the battery and operating the computer. An internal voltage regulator reduces the voltage to what the computer actually needs. The 12-volt DC is reduced to five volts to operate most of the computer circuitry.

Also, as the battery loses charge, its output voltage will drop. Using a regulator allows the circuits to receive a constant supply voltage at all times.

Upgrading the CPU is not an option on the PC5500 or virtually any other laptop since the chips are soldered in and the board would not support a different chip (other than maybe the same chip, but a faster speed).

Additional memory may be an option, depending on the present configuration of the computer. But, older laptops and notebooks generally had limited, or no, memory expansion slots. I was not able to find specific information on the PC5500, but I suspect the only "upgrade part" really being offered for this machine is a replacement battery.

Rick Nelson
Newport News, VA

ANSWER TO #129610 - DEC. 1996

In the Dec. '96 issue, James Bryden asked about test mode and reprogramming information for his Technophone MC905A/915A. There are two separate Technophone modes: MCA905 and MC915A. The MCA905 has eight NAMs and the MC915A has two NAMs. To make sure Mr. Bryden receives the correct information, I've included programming information for BOTH models. The "test mode code" and basic reprogramming steps are the same. This information will NOT tell you how to change the ESN of the phone. Technophone may be contacted at **516-576-2000**. Additional information may be found by connecting to www.10pht.com/radiophone/technophone/techno.html which makes available a software package for reprogramming.

Joe Grand

TECHNOPHONE MCA905, 985, 995

NOTES: This unit has 8 NAMS. The ESN prefix is 162 decimal & A5 hex.
Technophone: **516-576-2000**

NAM PROGRAMMING:
1. Turn phone on.
2. Enter # 0 0 0 0 0 0 # # 9 5 3 7 3 9 # STO 9 9 STO STO
3. Turn phone off.
4. Turn phone on again and it will display "Which NAM?"
5. Enter the NAM you want to program, 1 through 8, followed by the * key.
6. The first data entry will appear.
7. Press the * key to store and increment the step number.
8. Press SEND after step 08 when display reads "Save NAM?" to store the new data, phone will revert to "Which NAM?" at which point you can press END to complete and exit, or select another NAM.

PROGRAMMING DATA:

STEP #	# OF DIGITS/RANGE	DISPLAY	DESCRIPTION
01	0 OR 1	AMPS/TACS	PRESS 1 TO SELECT US SYSTEM
02	00000 - 32767	AREA ID	SYSTEM ID
03	10 DIGITS	NO	AREA CODE AND PHONE NUMBER
04	2 DIGITS	O/LOAD, CLASS	ACCESS OVERLOAD CLASS
05	2 DIGITS	GRP ID, MARK?	GROUP ID (10 IN USA)
06	0 OR 1	EXP ?	MIM MARK
07	333 OR 334	IPCH?	INITIAL PAGING CHANNEL
08	3 ALPHA NUMERIC	SYSTEM ID	SEE BELOW

Entry 07 is a convenience feature to distinguish between NAMs. You may enter a three letter abbreviation to identify each NAM. For instance, enter SFO for San Francisco. Use the letters on the keypad, each time you press a key the display will alternate. For example, the "2" key will scroll "2," "A," "B," "C." Press the # key when the letter you want appears on the display. To store SFO, enter 7777 STO, 3333 STO, 6666 STO.

SYSTEM SELECT: MENU 2 1 THEN MENU TO TOGGLE, CLR TO SET.

TECHNOPHONE MC915A

NOTES: This is a dual NAM unit. The ESN prefix is 162 decimal & A5 hex.
Technophone: 516-576-2000

NAM PROGRAMMING:
1. Turn phone on.
2. Enter # 0 0 0 0 0 0 # # 9 5 3 7 3 9 # STO 2 9 STO STO
3. Turn phone off.
4. Turn phone on again and it will display "Which NAM?"
5. Enter the NAM you want to program, 1 OR 2, followed by the * key.
6. The first data entry will appear.
7. Press the * key to store and increment the step number.
8. Press SEND after step 07 when display reads "Save NAM?" to store the new data, phone will revert to "Which NAM?" at which point you can press END to complete and exit, or select another NAM.

PROGRAMMING DATA:

STEP #	# OF DIGITS/RANGE	DISPLAY	DESCRIPTION
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03	2 DIGITS	O/LOAD, CLASS	ACCESS OVERLOAD CLASS
04	2 DIGITS	GRP ID, MARK?	GROUP ID (10 IN USA)
05	0 OR 1	EXP ?	MIM MARK
06	333 OR 334	IPCH?	INITIAL PAGING CHANNEL
07	3 ALPHA NUMERIC	SYSTEM ID	SEE BELOW

Entry 07 is a convenience feature to distinguish between NAMs. You may enter a three letter abbreviation to identify each NAM. For instance, enter SFO for San Francisco. Use the letters on the keypad, each time you press a key the display will alternate. For example, the "2" key will scroll "2," "A," "B," "C." Press the # key when the letter you want appears on the display. To store SFO, enter 7777 STO, 3333 STO, 6666 STO.

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Rubber Boot Included

Our Best Offer Ever on a High Quality Full Sized DMM

$19.00 any qty

General
Display: 3-1/2 Digit LCD, 21mm Figure Height with Automatic Polarity
Overrange Indication: 3 Least Significant Digits Blank
Temperature for Guaranteed Accuracy: 23°C±5°C RH<75%
Temperature Ranges:
Operating: 0°C to 40°C (32°F to 104°F)
Storage: -10°C to 50°C (14°F to 122°F)
Power: 9V Alkaline or Carbon-Zinc Battery(NEDA1604)
Low Battery Indication: BAT on Left of LCD Display
*Dimensions:*188mm long x 87mm wide x 33mm thick
Net Weight: 400g

DC Voltage (DCV)

Range:	Resolution:	Accuracy:
200mV	100µV	±(1%rdg+2dgts)
2000mV	1mV	
20V	10mV	
200V	100mV	
1000V	1V	

Maximum Allowable Input: 1000V DC or Peak AC.

DC Current (DCA)

Range:	Resolution:	Accuracy:
200µA	100nA	±(1.2%rdg+2dgts)
2000µA	1µA	
20mA	10µA	
200mA	100µA	
10A	10mA	±(1.2%rdg+2dgts)

Overload Protection: mA Input. 2A/250V fuse.

AC Voltage (ACV)

Range:	Resolution:	Accuracy:
200V	100mV	±(1.2%rdg+10dgts)
750V	1V	

Resistance (Ω)

Range:	Resolution:	Accuracy:
200Ω	100mΩ	±(1.2%rdg+2dgts)
2000Ω	1Ω	
20KΩ	10Ω	
200KΩ	100Ω	
2000KΩ	1KΩ	
20MΩ	10KΩ	±(2%rdg+10dgts)

Maximum Open Circuit Voltage: 2.8V

Diode Test
Measures forward voltage drop of a semiconductor junction in mV test current of 1.5mA Max.

ohFE Test
Measures transistor hFE.
Frequency Range: 45Hz-450Hz
Maximum Allowable Input: 750V rms
Response: Average Responding. Calibrated in rms of a Sine Wave.

CAT NO	DESCRIPTION	PRICE
9300G	Rugged High Quality DMM with Rubber Boot	$19.00

Switchable Scope Probe Sets

(Selectable X1/Ref/X10)
These high quality scope probe sets are for oscilloscopes up to 60MHz (model HP 9060) or 150MHz (model HP9150). Both sets include a handy storage pouch and include an IC test-hook adapter for the probe. The BNC connector rotates to avoid cable tangle or kink. Cable length is 1.4 meters.

		PRICE EACH		
CAT NO	DESCRIPTION	1	10	100
HP-9060	Scope Probe Set DC~60MHz	$16.49	$14.49	$11.58
HP-9150	Scope Probe Set DC~150MHz	24.95	21.95	18.62

CCD Camera - IR Responsive

As Low As $85!!

This black and white monochrome CCD Camera is totally contained on a PCB (70mm x 46mm). The lens is the tallest component on the board (27mm high from the back of the PCB) and it works with light as low as 0.1 lux. It is IR Responsive for use in total darkness. It comes with six IR LED's on board. It connects to any standard monitor, AUX or video input on a VCR or through a video modulator to a TV. Works with a REGULATED 12V power supply (11V-13V). Hooks up by connectiong three wires: red to 12V, black to ground (power & video) and brown to video signal output.

Power Supply Regulating Kit for CA-H34 This simple kit is designed to fit onto the back of the CA-H34 CCD camera. It resolves the problem of hooking up the camera to an UNREGULATED supply (which damages the camera) by providing safe regulated power from any 12V-14V DC supply. It also provides regulated 12V DC from a 12V AC source.

		PRICE EACH	
CAT NO	DESCRIPTION	1	5
CA-H34A	PCB Mounted IRCCD Camera	$99.00	$85.00
A34	Power Supply Regulating Kit	$6.95	----

PM-128: 3-1/2D LCD Digital Panel Meter; PM-129: 3-1/2D LED Digital Panel Meter

Features
- 200mV Full Scale Input Sensitivity
- PM-128 - Single 9VDC Operation
- PM-129 - Single 9VDC Operation
- Decimal Point Selectable
- PM-128 - 13mm Figure Height
- Automatic Polarity Indication
- Guaranteed Zero Reading for 0 Volt Input
- High Input Impedance (>100Mohm)

Specifications - PM-128/PM-129

Maximum Input	: 199.9mV DC
Maximum Display	: 1999 counts (3-1/2 Digits) w/Automatic Polarity Indication
Indication Method	: PM-128 - LCD Display PM-129 - LED Display
Measuring Method	: Dual-Slope Integration A/D Converter System *(cont.)*
(cont.)	
Overrange Indication	: "1" Shown in the Display
Reading Rate Time	: 2-3 Readings per sec.
Input Impedance	: >100 Mohm
Accuracy	: +-0.5% (23+-5°C, <80% RH)
Power Dissipation	: PM-128 - 1mA DC PM-129 - 60mA DC
Decimal Point	: Selectable w/Wire Jumper
Supply Voltage	: PM-128 - 9V DC PM-129 - 9V DC
Size	: 67mm x 44mm

Applications Include:
- Voltmeter
- Thermometer
- pH Meter
- dB Meter
- Watt Meter
- Current Meter
- Capacitance Meter
- LUX Meter
- LCR Meter
- Other Industrial & Domestic Uses

Positive Photo Resist Pre-Sensitized Printed Circuit Boards

These pre-sensitized printed circuit boards are ideal for small production runs. They provide high resolution and excellent line width control. High sensitive positive resist coated on 1oz. copper foil allows you to go direct from your computer plot or art work layout. No need to reverse art.

Single-Sided, 1oz. Copper Foil on Paper Phenolic Substrate

		PRICE EACH		
CAT NO	DESCRIPTION	1	10	50
PP101	100mm x 150mm/3.91" x 5.91"	$2.55	$1.90	$1.70
PP114	114mm x 165mm/4.6" x 6.6"	2.98	2.45	1.98
PP152	150mm x 250mm/5.91" x 9.84"	5.40	3.98	3.60
PP153	150mm x 300mm/5.91" x 11.81"	6.15	4.48	4.10
PP1212	305mm x 305mm/12" x 12"	12.78	10.65	8.52

Single-Sided, 1oz. Copper Foil on Fiberglass Substrate

		PRICE EACH		
CAT NO	DESCRIPTION	1	10	50
GS101	100mm x 150mm/3.91" x 5.91"	$ 3.90	$2.98	$2.60
GS114	114mm x 165mm/4.6" x 6.6"	4.80	3.49	3.20
GS152	150mm x 250mm/5.91" x 9.84"	8.69	5.98	5.78
GS153	150mm x 300mm/5.91" x 11.81"	10.20	7.20	6.80
GS1212	305mm x 305mm/12" x 12"	18.88	15.73	12.59

Double-Sided, 1oz. Copper Foil on Fiberglass Substrate

		PRICE EACH		
CAT NO	DESCRIPTION	1	10	50
GD101	100mm x 150mm/3.91" x 5.91"	$ 5.07	$3.68	$3.38
GD114	114mm x 165mm/4.6" x 6.6"	5.95	4.29	3.99
GD152	150mm x 250mm/5.91" x 9.84"	10.47	7.39	6.98
GD153	150mm x 300mm/5.91" x 11.81"	11.95	8.69	8.30
GD1212	305mm x 305mm/12" x 12"	22.09	18.35	14.68

Developer

This product is used as the developer on our positive photo-resist printed circuit boards. Includes instructions. 50 gram package, mixes with water, makes 1 quart.

		PRICE EACH		
CAT NO	DESCRIPTION	1	10	25
POSDEV	Positive Developer	$ .95	$ .80	$ .50

Etching Tank

This handy etching system will handle PC boards up to 8" x 9", two at a time. Ideal for etching your PCB's! System includes an air pump for etchant agitation, a thermostatically controlled heater for keeping etchant at optimum temperature and a tank that holds 1.35 gallons of etchant. A tight fitting lid is also supplied to prevent evaporation when system is not being used. Typical etching time is reduced to 4 minutes on 1oz. copper board!

CAT NO	DESCRIPTION	PRICE
12-700	Etch Tank System	$37.95

REDUCES ETCHING TIME!

Etching Chemicals/ Ferric Chloride

A dry concentrate that mixes with water to make 1 pint of etchant, enough to etch 400 sq. inches of 1oz board.

		PRICE EACH	
CAT NO	DESCRIPTION	1	5
ER-3	Makes 1 pint	$3.50	$2.75

Digital Panel Meters (LCD & LED)

3-1/2 Digit LCD 3-1/2 Digit LED 4-1/2 Digit LCD

PM-328: 4-1/2D LCD Digital Panel Meter

Don't let the prices fool you. These digital panel meters are not surplus, so even if you design them into an ongoing manufactured product, you can be assured of continued availability. These high quality digital panel meters are decimal point selectable with guaranteed zero reading at zero volts input.

Specifications - PM-328

Maximum Input	: 199.99mV DC
Maximum Display	: 19999 counts (4-1/2 Digits) w/Automatic Polarity Indication
Indication Method	: LCD Display
Overrange Indication	: "1" Shown in the Display
Input Impedance	: >100 Mohm
Accuracy	: +-0.05% (23+-5°C, <80% RH)
Power Dissipation	: 1mA DC
Decimal Point	: Selectable w/Wire Jumper
Supply Voltage	: 9V DC
Size	: 67mm x 44mm

Features:
- 200.00mV Full Scale Input Sensitivity
- Single 9V DC Operation
- Decimal Point Selectable
- 11mm LCD Figure Height
- Automatic Polarity Indication
- Low Battery Detection and Indication
- High Input Impedance (>100 Mohm)

		PRICE EACH				
CAT NO	DESCRIPTION	1	10	25	100	250
PM-128	3-1/2 Digit LCD Panel Meter	$ 9.90	$ 7.09	$ 6.40	$ 5.86	$ 5.25
PM-129	3-1/2 Digit LED Panel Meter	11.49	9.54	8.67	7.95	6.95
PM-328	4-1/2 Digit LCD Panel Meter	19.88	16.40	14.90	13.66	11.93

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iCan Reaction Tune Another Receiver!

Reaction Tune the NEW ICOM IC-R10

Use the OptoLinx for computer controlling the ICOM IC-R10 $129.00

Computer Not Included

Another radio to tune, another reason to purchase the *Scout*.

Until now the AOR AR8000/2700 were the only hand held scanners to take advantage of the ***Scout's*** Patented Reaction Tune function. The Scout can now tune the new ICOM IC-R10 hand held scanner (shown below). Connection is easy: No modifications required - No custom cables to buy - Just plug and play.

Scanner hobbyists and communication professionals benefit from the ***Scout's*** unique functions. Whether you're searching for new frequencies in your neighborhood, or testing for interference, the ***Scout*** is the ultimate communications tool.

Armed with a 400 frequency memory register, the ***Scout*** does not record duplicate frequencies, instead it coordinates repeated frequencies into a hit register storing up to 255 hits per frequency. Attach it to your belt and begin your day, the ***Scout*** will alert you when a signal is received by its beeper or vibrator function.

You won't miss a thing with Reaction Tune. The ***Scout's*** CI-V compatible output allows it to interface to the AOR AR2700/AR8000, ICOM R7000, R7100, R8500, R9000 and now the new IC-R10 (shown oposite). The ***Scout*** captures the frequency, then sends the serial data to the receiver and tunes the scanner to the frequency for instant monitoring in less than one second. Recorded frequencies can be downloaded to a PC using the optional OptoLinx universal interface •

SPECIFICATIONS

- 10MHz - 1.4GHz frequency coverage
- Stores and records 400 frequencies in memory with 255 hits for each
- Interface to a PC for frequency download using optional OptoLinx PC interface
- Distinctive beeps indicate frequency hits, pager style vibrator for discreet recording
- Automatic EL backlight for night operation
- 16 segment RF signal strength bargraph
- Frequencies are automatically saved when unit is turned off
- Reaction Tune the ICOM R7000, R7100, R8500, R9000, IC-R10, and AOR AR2700, AR8000, and the Radio Shack Pro 2005/6 using the Optoelectronics OS456, Radio Shack Pro 2035/42 using the Optoelectronics OS535

$449 Includes Scout, DB32 Antenna, CC30 Case & Spectrum CD

Scout with ICOM IC-R10
Mono Cable required (shown)

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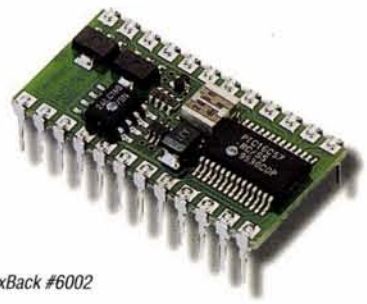
BASIC STAMP® COMPUTERS

Tiny computers run PBASIC™ programs

Little Green Men from Mars

Bjarne Bergheim, Ken Christian, William Jackson, and Ben Strayer worked on "the Flying Saucer Project" at the University of California, Irvine. Their project, which used two BASIC Stamp II modules, was a literal flying saucer. Although not as dramatic as Hollywood versions, their saucer did indeed fly! And fortunately, it didn't come on Independence Day.



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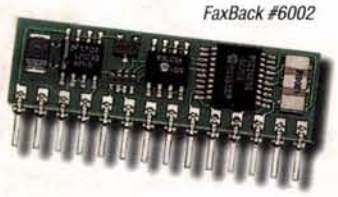

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BS1-IC™ Module $34

- 8 I/O lines
- 80 PBASIC instructions max.
- 2000 instructions/sec.
- 2400 baud serial I/O
- 14-pin SIP module

Familiar PBASIC language with I/O instructions for pushbuttons, EEPROM access, potentiometers, pulse measurement, PWM, serial I/O, sound, etc.

BS2-IC™ Module $49

- 16 I/O lines
- 500 PBASIC™ instructions max.
- 4000 instructions/sec.
- 50k baud serial I/O
- 24-pin DIP module

Similar language as BS1, plus touch-tones, frequency generation, pulse counting, serial shift registers, X-10 powerline control, etc. I/O functions common to both modules have a higher resolution on the BS2-IC, due to its faster clock speed. With its rich feature set, the BS2-IC is the most popular BASIC Stamp we make.

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New! 4-line Serial LCD $109

New 4-line serial LCD display is fun and useful for projects that require interaction with people. The display only takes one I/O line to operate, and can be controlled using simple SEROUT instructions in your BASIC Stamp programs.

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Take advantage of all the cool features of the Basic Stamp 2. This Starter kit includes the BS2-IC, carrier board, manual, software, and programming cable.

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